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The Analysis of Investment Theories and Application of Tobin-Q Model to Second-hand Dry Bulk and Tanker Ship Investments

by

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ABSTRACT

Ship investment has two essential components: (1) Purchasing and selling shipping assets (i.e., ships) to ensure a certain capacity of marketable shipping service while optimising the investment timing to achieve better deals in asset price arbitrage (e.g., counter-cyclical asset play); (2) operating ships to generate revenues from shipping services (carrying cargoes) while sustaining a strong relationship with charterers as cargo owners or traders. During economic downturns of the last few decades, many ship investors observed that the former component of revenue generation (asset price arbitrage) contributes a much significant fraction of net revenue comparing to the latter part (operating income). For example, a Capesize dry bulk carrier would be sold at US$140 million during June 2008, and the same asset would be valued at just US$40 million in December 2008, only six months later. The investor lost US$100 million amount of asset value, and that has not returned back yet (by October 2019). In other words, prices of the market (mark-to-market value) do not efficiently represent a robust and credible value of shipping assets, particularly in potential asset bubbles during the prosperity of freight markets. Accordingly, an investor would not be advised on investment timing based on market prices.

For mitigating the biasedness of asset prices in the sale and purchase market, investors need a forward-looking instrument to shed light on the robustness and durability of ship prices at any time and to develop an asset management strategy in line with long-term prospects of the market. In this regard, a valuation test ratio, the shipping Q index, has been proposed to monitor asset value shortfalls as well as overvaluations and to identify mismatch of market prices and long-term values of shipping assets.

In ship investment literature, investment decisions are mainly investigated from a perspective of the relationship among the shipping markets (newbuilding, second-hand,

freight, and scrap) and their impacts on asset price valuation, the timing of investments and market entry and exit conditions. Although the shipping industry is highly capital intensive and attracts a high amount of investment, very limited research has been undertaken focusing on the discrepancy between market prices and the long-term nominal value of a ship reflecting any mispricing, which in turn sheds light on investment timing and market entry-exit decision. Therefore, this study investigated the major investment theories and their applicability to the ship investments in the context of maximizing the investment return by reaching the optimum level subject to investment return.

Considering the fundamental characteristic of shipping markets, the Q theory of investment was adapted to the ship investment in this study. A “Shipping Q” indicator based on the Tobin-Q theory was developed for dry bulk and tanker carriers as the ratio of the nominal price of the ship to the market price. The computation of the nominal price of a ship was undertaken by calculating the cash flow for each vessel segment from 1990 to 2017. For each year in the life of the ship, the anticipated revenue and expenditure were determined. The net cash flow, which is revenue (time-charter rate) less expenditure (operational expenses), was then discounted by means of a discount factor (long-term government bond yields of 10 years). The value of the ship was calculated as the sum of each of the discounted cash flows plus the discounted residual value, which was the demolition value of the ship in this model.

This study revealed two main findings. First, the results indicated that the Shipping Q indicator was a robust and significant tool to explore market entry and exit timings through the difference between market prices and the long-term nominal value of ships. In contrast to the mainstream belief, invest when freight rates are high, Shipping Q proved that the investment becomes less profitable after a certain level based on the ratio of market price to the nominal value of a ship. Second, the Shipping Q indicator was optimized subject to return maximization, which provided a certain level of investment return maximization. The optimization of the indicator created the opportunity for market participants to manage their shipping asset portfolio with better insights into the direction of second-hand ship prices.

The findings of this study contribute to the asset valuation concept, both theoretically and empirically. Theoretically, it contributes to the literature of firm-level investments in fixed capital by producing an analytical indicator based on the empirical data for ship investment. Empirically, the Shipping Q is able to interpret the future second-hand ship market considering the changes in the time-charter rate and nominal value of a ship. Moreover, the optimized Shipping Q leads to a certain level of maximization of investment return. Having a robust tool to evaluate the future second-hand ship market could contribute to efficient asset management along with the efficient use of financial funds.

The thesis has a number of limitations and recommendations for future studies; firstly, the SQ indicator inherently carries asymmetric information. Secondly, the sample data is confined to industry-level data due to unavailable firm-level data. Further studies regarding firm-level analysis are highly recommended in case of accessibility of the data. Thirdly, the thesis merely adapted the investment models to second-hand ships, has not suggested a new investment model. Fourthly, SQ indicator optimization analysis conducted for 5-year-old vessel types due to insufficient 10- and 15-year-old vessel data. In addition to the limitations, there are several recommendations to future studies, additional research on the back-testing the predictability of the SQ indicator with various methods that could be executed. Secondly, a study could analyse the effectiveness of the SQ indicator for different ship types, such as container ships.

LIST OF ABBREVIATIONS

NB	Newbuilding Ship
SH	Second-hand Ship
Q	Tobin-Q Theory of Investment
SQ	Shipping Q
TC	Time Charter Rate
GDP	Gross Domestic Product
UNCTAD	United Nations Conference on Trade and Development
GFC	Global Financial Crisis
IMF	International Monetary Fund
DWT	Dead-weight Tons
ROA	Real Option Analysis
NPV	Net Present Value
DCF	Discounted Cash Flow
P/E	Price to Earnings Ratio
GARCH	Generalized Autoregressive Conditional Heteroscedasticity
LIBOR	London Interbank Offered Rate
VLCC	Very Large Crude Carrier
ULCC	Ultra Large Crude Carrier

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Chapter 1 Introduction

1.1 Background of Study

The importance of the shipping industry to the economy and trade is an indisputable fact, and researches on maritime economics need to increase to understand the dynamics in the markets substantially. These markets are classified as the newbuilding market where new ships are traded; the sale and purchase (S&P market) market trades the second-hand ships; the freight market deals with prices for shipping services; and the demolition (scrap) market deals with old ship scrapping activities (Duru, 2018; Stopford, 2009). A considerable amount of literature has been published on the complicated and grid relationship of the shipping markets (G. Dikos et al., 2003; P. B. Marlow, 1991b; Tsolakis et al., 2003). Results from earlier studies demonstrated a consistent and robust association between freight rate, newbuilding prices, and second-hand prices, and lastly, demolition prices. The significant change in freight rate is expected to be closely followed by second-hand ship prices, newbuilding prices, and demolition price change accordingly. During the peak level period, 2003-2008, while freight rate of dry bulk and tanker experienced historic peak levels, second-hand prices and newbuilding prices also significantly increased.

The changes in freight rate and asset prices have a significant impact on ship investment decisions in second-hand and newbuilding markets (Alizadeh et al., 2007; Gkochari, 2015). The short- and long-term freight rate shifts are the result of a constant adjustment to a supply and demand balance, which is cyclical in nature (Chistè et al., 2014). The cyclical nature of the bulk market underlines the importance of the timing of investments as asset prices reflect market conditions (Lorange, 2001). Despite the cyclical nature of the market and the importance of market entry or exit timing, investment decisions are often based on intuition (Scarsi, 2007) or imitation of the investment behaviour of peers in practice (N. Papapostolou et al., 2017) due to uncertain future incomes and the ownership structure in maritime industry (Harlaftis, 2007). This leads to irrational investment behaviour and asset bubbles in the shipping market, such as the ones observed in the period between 2003 and 2008 (Duru, 2013). Besides holding complex investment structure in the shipping industry, it is also one of the rare industries having very intensive and active two investment markets: second-hand and newbuilding markets, wherein both markets, the main assets are traded (Tsolakis et al., 2003). The relationship between the new building and the second-hand market is crucial in terms of shipping asset management. These two markets are not their substitutive markets; however, when the demand for shipping services rise significantly and far above the expected increase, then these two markets become rivals. For example, during the historical peak from 2003-2008, Clarkson Shipping Intelligence Network[1] data states that the 5-year-old second-hand price of a Suezmax tanker (160K DWT) was constantly over the price of a newbuilding Suezmax tanker (156-158K DWT) till September 2008, when the impact of the GFC was strongly felt in the shipping markets. The primary motivation behind the price discrepancy between newbuilding and second-hand ship prices is the desire to own a second-hand ship by skipping the newbuilding delivery time lag and benefit from the increased freight rates (Merikas et al., 2008).

The price volatility in second-hand markets draws attention to the valuation of shipping assets. The valuation of ships is determined by the expected future profits earned by

[1] The data has been downloaded 09/11/2017.

trading the vessel and discounted back to the present value (David Glen et al., 2010). In the theory of value concept, the value of an asset is divided into two distinct definitions: market price and natural price. The market price is the identified value of an asset while it changes ownership, it may rise and fall due to shortages and abundance in the market, or changes of taste and supply, and speculation (Foley, 2009). The natural price is determined by Smith (1776) as the price is more or less what it cost. The main differences between the market price and the natural price are stated as "The actual price at which any commodity is commonly sold is called its market price. It may either be above, or below, or the same with its natural price" (Smith, 1776, p. 74). It is most likely known that market price is expected to converge to the natural price level according to the classical economist view.

The valuation problem is also highly linked to the theory of investment models. As the model reveals the approximate value of an asset, then the level of investment can be determined. The neoclassical investment theories worked on various aspects of investment determinants to estimate the approximate value of total investment. For example, the accelerator investment model assumes that as the actual capital stock adjusts instantaneously to the desired capital, the investment level needs to be managed according to this fundamental (Chenery, 1952; Koyck, 1954; Tinbergen, 1938). Profit theory considered that the investment decisions are made by considering the present value of expected future profits since present profits are most likely to reflect future profits (Grunfeld, 1960). Liquidity theory stated that the cash flow would dominate the level of investment, and the supply of funds schedule rises sharply at the point where internal funds are exhausted (Jorgenson et al., 1968). Neoclassical theory brought the concept of optimal capital accumulation to maximize the utility of a stream of consumption. Besides, the neoclassical theory stated that the investment process is dynamic; the optimal capital accumulation might change (Jorgenson, 1963, 1967, 1971). Lastly, the Tobin Q model developed an investment model that considers the market value and the book value (Brainard et al., 1968; Tobin, 1969, 1978). The model raised an indicator, Q variable, which is the ratio of the market value of firm capital to the replacement cost of capital. It is assumed that if Q variable goes over equilibrium level 1.00, then the firm increases the investment; if Q is below equilibrium level 1.00, then the firm reduces the capital stock or disinvest. Tobin Q investment model is the one among firm-level investment models that focusses on the dynamic value of the capital and interpret investment/disinvestment options with an indicator, Q variable. Q model is applied to various industries with amendments, for example, it has been used to measure ownership structure and investment performance (Morck et al., 1988), and used as a financial performance indicator (Li et al., 2004). In this study, the application of theories has been developed, and the Q variable is adapted to ship investments to determine asset sell and buy levels in the second-hand market of dry bulk and tanker carriers. However, investment theories have not been developed.

In the adaptation process of the Q model in ship investments, Shipping Q, hereinafter to be called SQ, the indicator was created as an indicator to estimate the future movement of the shipping markets. SQ is the ratio of the market price of a ship, which is the second-hand price, to the calculated value of a ship, which is the nominal price. According to the theory of value, the calculated value of a ship can be accepted as an estimated natural price of a ship, which is calculated by reflecting future cash flows assuming the mean-reverting ship market. The SQ indicator is interpreted as when the market price is higher than the nominal price; then, there might be overvaluation, which might lead to an asset bubble in the following period. Therefore, SQ indicator signals to sell where the indicator is above the equilibrium level. If the SQ indicator is lower than the equilibrium price, where the market value is lower than the nominal price, then it signals to buy. Principally, the market price is expected to go back toward the natural price level. SQ indicator indicates the market ups and downs to catch up with the opportunities to enter and exit from the market.

This study was triggered after discovering the gap in the literature regarding shipping investment, and the need for a guiding indicator in the investment market due to highly risky and capital-intensive industry. To address this gap, this study will initially examine the firm-level investment literature and express the foundation of the Tobin Q model to apply to ship investments of dry bulk and tanker. Following the literature review, the Q variable will be adapted to the shipping industry. The calculated indicator will be evaluated for each vessel tonnage and age (5, 10- and 15-year- old). Moreover, following the Tobin Q model application, optimization subject to investment return will be determined for each vessel type for the various upper and lower bands to outline the SQ indicator role in the combinations of the buy and sell signals using which would maximize the shipowner's profit for a 25-year period.

1.2 Research Questions

Based on the research background, the primary research question (PRQ) of this research is formed, and three secondary research questions (SRQ) are generated to answer the primary research question.

The primary research question and secondary questions are as follow:

PRQ: How can second-hand ships be evaluated with conventional investment modelling to detect over and undervaluation?

SRQ1: What is the foundation of the major investment theories that apply to second-hand ship investments?

SRQ2: How can the chosen investment model be adapted to the second-hand dry bulk and tanker carrier on a yearly and monthly basis?

SRQ3: How can the identified investment model be optimized for the second-hand dry bulk and tanker carrier investments subject to investment return?

1.3 Objectives of the Study

The objectives of this study are outlined in two parts: the primary objective of this study is to adapt the Q model of investment to the shipping industry and calculate the SQ indicator. The second objective is to optimize the SQ indicator for dry bulker and tanker shipping subject to investment return.

1. Examine Q theory in-depth lead this study to be able to adapt the model to second-hand ship investments. In the literature, the adaptation of the firm-level investment theories into the shipping industry is rarely seen. It is observed that ship investments are mostly studied in terms of shipping markets relationship (G. Dikos et al., 2003), investment timing with second-hand ship price-earnings (P/E) ratio (Alizadeh et al., 2007), and capital budgeting analysis through applying real option analysis (Bendall et al., 2007). The indicator rooted in the firm-level investment theories has not been applied in ship investment before; therefore, this method might lead to robust and significant results due to utilizing the dynamic valuation structure of the asset.

   The Q theory of investment is the one created by Brainard et al. (1968) and Tobin

(1969, 1978) to address the pitfalls of the neoclassical theory of investment. The theory stands out with its several distinctive features; first, the theory considers the cost of the adjustment process of investment. Second, the Q variable explains the link between a firm's investment and its marginal net worth with respect to the capital stock, which enables the investors to be advised about future investment opportunities. Lastly, the theory attracts the attention of scholars with high explanatory power in the empirical analyses (Kilponen et al., 2016). More importantly, Q theory of investment provides an indicator, Q variable, to adjust the level of investment in a dynamic mechanism. In this study, utilizing from the Q variable and adapting it to the SQ indicator is a new and innovative application in ship investment literature.

To address the primary objective, the SQ indicator is created as the ratio of second-hand ship prices to the calculated value of a ship. The calculated value of a ship as an estimated natural price of a ship is found by reflecting future cash flows assuming the mean-reverting ship market. The SQ indicator is calculated yearly and monthly for dry bulk and tanker carrier and expected to catch up with the significant buy and sell signal with yearly SQ indicator and elaborate the main argument to show the gap between short-run pricing (market value) and the long-term valuation. To obtain definitive evidence about the valuation gap between nominal price and the market price of the second-hand ships, the monthly SQ indicator is to be analysed. The monthly SQ indicator also provides a more significant data set, which is more appropriate for long term data analysis.

2. The SQ indicator is aimed to be optimized subject to total investment return within a specific term, which is from 1990 to 2010. The SQ indicator is an

optimized subject to maximize the return, where utilized the value maximization principles. The main principle of expected value maximization states that a rational investor, when faced with several investment alternatives, acts to select an investment which maximizes the expected value of wealth (Boyd et al., 2004; Morgenstern et al., 1953). Following this principle, monthly SQ is optimized subject to total investment return, and therefore, an upper and lower band of buy and sell signals for dry bulk and tanker carriers are determined.

The approximate level of optimization is identified through the trial method. The SQ indicator asserts that if the value of the SQ indicator exceeds the equilibrium level, it is a signal to sell. In the optimization process, the upper and lower levels around the equilibrium level 1.00 are tested to reveal the maximum investment return level. To identify the sell signal level of the dry bulk and tanker vessels, the level above 1.00 is planned to be tested; for the buy signal level of the dry bulk and tanker vessels, the level below 1.00 is planned to be tested. Regarding the application of the optimization in the SQ indicator, the optimization scenario is organized and applied for each vessel type separately from 1995 to 2015 and assumed that having the same initial capital, 100 million USD, and seeking to buy a 5-year-old vessel. Where the first buy signal comes, after a three-month waiting process, the ship is purchased with the second-hand market price. The cash outflow is calculated, and operational income is counted as cash inflow throughout the process, and the ship operates until the first sell signal. Operational income is calculated as revenue (time charter rate multiplied by 350) minus operating expenses (daily operating expenses multiplied by 365). After the first sell signal, again, a three-month time-lapse is counted, and the ship is sold at the corresponding second-hand price. Sell income is added to the cash flow. The buy and sell operations continue from 1995 to 2015. At the end of 2015, if the asset is still not sold, then it is accepted as sold at the corresponding second-hand price in the market. Eventually, investment performance for each vessel will be tested at different upper and lower bands, and the highest investment return band is identified as an optimized level of investment.

1.4 Research Significance and Contribution

The research will contribute in several ways to an understanding of the application of investment theories into the shipping industry and provide analysis for strategic investment decisions in bulk shipping. First, this study analyses the firm-level investment theories and discusses their application to the shipping industry from an asset management perspective. The firm-level investments in fixed capital are central to the understanding of economic activities. The considerable fluctuation in investment expenditures can lead to aggregate fluctuations in the industry and the economy. Inefficient firm-level investments closely link to reduced long-run industrial growth, and this might lead to a waste of resources in the short term. The firm-level investment decision is thus an essential topic for steady industrial growth along with economic growth. To better understand the investment decision mechanism, applying the major investment theories to either firm-level studies or industry-level studies is crucial in the context of maximizing the profitability by reaching an optimum level and asset price valuation link. In the literature, the major firm-level investment theories have been widely applied to industry-level studies, such as manufacturing, finance, banking, housing, and airline; and most of the studies proved that the explanatory power of investment theories could not be ignored.

Second, the application of firm-level investment theories into the shipping industry has not been a widely used method in the literature. Therefore, by applying the Q model in the shipping industry, this research will be able to apply a microeconomic approach to the shipping industry. This will highlight the ship investment decisions regarding investment timing with a rule-based asset management algorithm. Also, the outcome of this research will contribute to the dry bulk and tanker investment decision mechanism by developing a buy and sell warning system. Having an empirical analysis of ship investment management will dissolve complex market signals with advanced market forecasting tools.

Thirdly, the optimization of the SQ indicator will determine an approximate upper and lower level to produce a buy and sell strategy for dry bulk and tanker ships. Results of optimization will identify mispricing, which in turn would lead to an asset play opportunity. In other words, the results will provide margins where investment return is expected to be maximized for dry bulk and tanker second-hand vessels.

Considering the proposed contribution and significance of the research to the maritime economics and shipping industry investment literature, the beneficiaries of this research can be listed as bulk ship owners, new market entrants to bulk shipping, financial institutions which loan to the investors, shipyards, and policymakers from various perspectives. Firstly, the SQ indicator as an adapted indicator can be used as a rule-based management tool, which eases the investment decision-making process with a robust and significant approach. Secondly, being able to interpret value mismatch with a developed tool will give opportunities to market participants to take preliminary action when the asset is overvalued or undervalued. Therefore, existing ship owners and new entrants to the market can benefit from the outcome of this research for their market entry and exit decisions in the second-hand dry bulk and tanker markets. Thirdly, the market participant might utilize the optimized SQ results to determine the maximized level of investment return.

1.5 Research Methodology

This research mainly aimed to examine the valuation mismatches of the second-hand ship prices between the nominal price and the market price with an adapted model based on firm-level investment models. To achieve this primary aim, this research employed several sets of methods; firstly, the adaptation of Tobin Q model (Brainard et al., 1968; Tobin, 1969) to the SQ indicator was outlined with the mean reversion approach and discounted cash flow method, which was calculated by income-based approach (Baum et al., 2013).

Secondly, the optimization subject to return maximization was applied to the calculated SQ indicator (Boyd et al., 2004). In optimization analysis, the SQ indicator was tested for the different upper and lower bands to find out the best combination to invest and gain maximum return for the given data set.

1.6 Structure of the Thesis

This thesis consists of 6 chapters, which are outlined as follows. Chapter 2 begins by laying out the theoretical concepts of the research and an extensive literature review on the firm-level investment theories and the empirical studies on ship investments and related shipping markets. The major firm-level investment theories include fundamental approaches to investment theories, accelerator theory, expected profit theory, liquidity theory, neoclassical theory, and Q theory of investment, which are elaborated with their main formulations, features, and drawbacks. The empirical studies on ship investments provide both dry bulk and tanker studies on ship price valuation, investments into the second-hand, and correlations between asset price and market price volatility. Chapter 3 introduces the investment model application to the second-hand markets, the SQ indicator calculation method, and optimization of the SQ indicator. Also, the source of the sample data and variables are supplied in Chapter 3. Chapter 4 presents the results of the SQ indicator calculation in a yearly and monthly format for both dry bulk and tanker carriers. Along with the results of the SQ indicator, the descriptive statistic for each sample (dry bulk and tanker monthly; dry bulk and tanker yearly) and correlation analysis. Chapter 5 presents the optimization process of the SQ indicator along with providing the optimization results of monthly SQ indicator of dry bulk and tanker carriers. Chapter 6 concludes the research, including a summary of findings of the literature and the empirical application, contribution of the thesis, limitation, and recommendation of future studies. The flow of the thesis is portrayed in Figure 1.1.

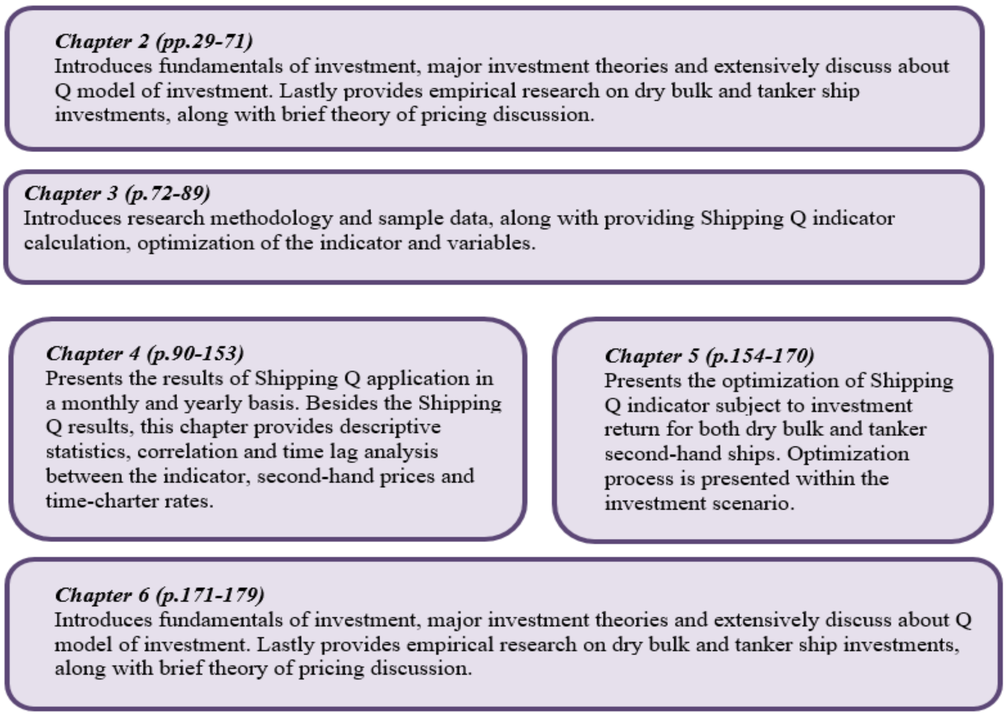


Figure 1.1 Structure of the Thesis

Chapter 2 Literature Review

2.1 Introduction

The theory of firm-level investment, ship investments, and the theory of ship pricing literature are systematically reviewed in Chapter 2. In Section 2.2, fundamental concepts of investments, the definition of investment, types of investment, and main features of investment; are reviewed. Section 2.3 attempts to provide extensive literature on major firm-level investment theories: accelerator, expected profit, liquidity, neoclassical, and Q theory of investment. Section 2.4 reviews empirical studies on dry bulk and tanker ship investments, and Section 2.5 provides a further argument about the theory of ship pricing in an extensive literature. Lastly, Section 2.6 summarizes Chapter 2.

2.2 Concept of Investment

Investment is a broad concept widely used in business management. "*An investment is the current commitment of money or other resources in the expectation of reaping future benefits*."(Bodie et al., 2014, p. 1). The general concept of investment emphasizes the direct link with current behavior and future expectation of the investors. Nickell (1978) also states that the investment is made to gain future benefits, namely profits by purchasing assets or investing in various tools. The common ground of the definition of investment is that the sources are directed to some valuable sources for future benefits or future profits, which is expected to be gained.

As suggested by Nickell (1978), investments can be classified into two groups in terms of categories and levels. More specifically, at the individual level, investment decisions are usually made to improve future consumption by sacrificing the current consumption. The firm-level investment may vary from investment in human capital, including their trainees, investment in know-how via research and development, investments in stocks of finished goods or raw materials, and investment to the fixed capital stock investments such as plant, and equipment (Nickell, 1978). At the country level, investment decisions are motivated by long term economic development of a country via fixed capital investments. The role of investment in macroeconomic level, which is for the economic growth of nations, was discussed by many scholars such as Gurley et al. (1955), King et al. (1993a, 1993b); Levine (2004). These studies stated that investments could promote the higher economic growth of the nations; there is a robust and significant correlation. Also, P. B. Marlow (1991b) emphasized that British governments engaged in the encouragement of investments to obtain a higher level of economic growth after the 1950s.

Besides, there are common features of investments that apply to each type. First, most of the investments are partially or entirely irreversible; the investor has to bear with some initial sunk costs that might occur in case of changing the mind. Second, there is high uncertainty and risks over future returns, especially in shipping investments. The investors always have the right to postpone the investment to get more information to reduce the risks; however, there is never complete certainty about the future (Dixit et al., 1994).

2.3 Firm-Level Investment Theories

The firm-level investments in fixed capital are central to the understanding of economic activities. The considerable fluctuation in investment expenditures can lead to aggregate fluctuations in the industry and the economy. Inefficient firm-level investment policies can be linked to reduced long-run industrial growth, and this might lead to a waste of sources in the short term. Investment behavior is thus an essential topic on steady industrial growth along with economic growth. In the literature, there are five mainstream firm-level investment theories: accelerator, expected profit, liquidity, neoclassical, and Q theory of investment. The firm-level investment theories seem to have stagnated after the last quarter of the 20th century[2]. Investment theories between the 1900s and 1970s have taken a substantial role in the literature and showed significant progress. However, after the 1970s, the development of new investment theories has slowed down, and most of the subsequent studies dealt with the introduction of a new approach to existing theories, rather than suggesting a different theoretical approach. Some economists, such as Chang (2014) and McCloskey (2002, 2006), argue that the innovative growth process of economic thought slowed down in the 21st century.

Although the growth of economic thought in investment theories is slackened, still the application of traditional firm-level investment theories in the shipping industry is the absence in the literature. The main reason for absence is that the ship investments in the literature started receiving increasing attention of researchers from the 1950s to now as a consequence of data availability, the increasing role of shipping during globalization. This inference brings a more profound question which is, why the shipping industry traditionally been absent from mainstream research in economics and economic history, although shipping has a very long and fascinating history in world history (Paine, 2014). This question has been widely argued by Harlaftis et al. (2012). The reason is the common

[2] Besides five major firm level investment theories, time series investment model derived by Kopcke (2001) where the model considers the trends and cycles evident in recent experience which are sufficiently stable to describe the course of the investment in the future. The model is formulated by as $I_t = \sum_{i=1}^{n} a_i \, I_{t-1} + \sum_{i=0}^{n} b_i \, Q_{t-1}$, I is investment, Q is output. However, the model has not been widely applied by other scholars.

neglect of the service sector in economic and historical research. Studies of the emergence of modern economic growth in industrializing economies usually focus on manufacturing, while seldom emphasizing the importance of service sector activities. The second reason that the maritime industries have been absent from mainstream research is their international character, which blurs the links to individual economies. The product of shipping, sea transport, takes place beyond national boundaries, and its income is earned abroad, removed from the economic structures of a specific country. It is indicative that economists analyzing national economies have classified shipping income as ‘invisible earnings’. However, more recently, this has changed, and OECD member countries report international transport by sea services in their account (OECD, 2001). The third reason for the invisibility of the business of shipping is that it is ‘intangible’, and its absence from the core of economic analysis mirrors the situation of many other service industries.

In the light of provided insight on the progress of investment theories and literature of ship investments, major investment theories, and their foundations have been systematically reviewed in the following section. Accelerator, Expected Profit, Liquidity, and Neoclassical theories are individually reviewed to provide evolvement of theories from the fundamental levels to the advanced level. Tobin Q theory, as the latest and advanced model, eliminates the drawbacks of the previous models to reveal investment decision mechanisms within the dynamic structure.

2.3.1 Fundamental Approaches to Investment Theories

Keynes (1936) and Fisher (1930) argued that investments are made until the present value of expected future revenues is equal to the opportunity cost of capital (J. Eklund, 2013).

In other words, the investments should be made until the net present value (NPV) is equal to zero. NPV was formalized and popularized by Irving Fisher, in his 1907 "*The Rate of Interest*". An investment is expected to generate a stream of future cash flows, $C(t)$. Since the investment, I, represents an outlay at time 0, this can be expressed as a negative cash flow, $-C_0$. The net present value can then be written as:

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_0, \qquad (2.1)$$

Where

C_t = Net cash inflow during the period t

C_0 = Total initial investment costs

r = the opportunity cost of capital (discount rate)

As long as the expected return on investment, abbreviated as i, is above the opportunity cost of capital (discount rate), r, then the investment will be worthwhile. In the case of the cost of opportunity cost is equal to the expected return on investment, then the net present value will be equal to zero. The expected return on investment, i, is equivalent to Keynes' marginal efficiency of capital and Fisher's internal rate of return.

Net present value (NPV) and discounted cash flow (DCF) analysis have been widely applied as investment decision-making tools by the firms. They evaluate the projects; if the value of the NPV is greater than or equal to 0, then the project can be accepted. However, the static DCF analysis overlooks significant strategic concerns about future uncertainty and management's flexibility to respond to situations that differ from the expected scenario of future cash flows. It implies an inflexible management strategy, which is not a reflection of real-world competitive interactions and the operating environment of most firms, particularly those operating in multiple currency environments such as shipping. As an dynamic alternative to static DCF method, the dynamic real option analysis (ROA) method introduced by Dixit et al. (1994) and widely applied in shipping industry, for example, G. Dikos (2008); G. Dikos et al. (2003), Gkochari (2015), Dixit et al. (1994), Hopp et al. (2004) Bendall et al. (2007). The ROA is treated as an alternative method to manage ship investment strategies under uncertainty and irreversibility with additional options which can be exchanged with low risky income stream associated with one strategy with that of another strategy (Bendall et al., 2007). The analysis is derived initially from the real option theory and applied to the shipping industry as an analysing method. ROA has not been examined as part of investment theories since it is not treated as an investment model.

2.3.2 Accelerator Theory

The accelerator theory[3] was introduced by Clark (1917). His study built on Mitchell (1913)'s book, Business Cycles, to present the underlying technical facts of consumption demand relationship between industry-level investment in a precise quantitative formulation (Clark, 1917). In other words, he mainly analyzed the effect of fluctuating consumer demand on the supply of manufacturing firms and its accelerator business impact on several industries. He stated that "*Diminution can convert a slackening of the rate of growth in one industry into an absolute decline in another*." (Clark, 1917, p. 218). His study goes back to a century ago, needs to be interpreted based on the conditions of that time, whereby capital and factors of production were not mobile and economic fluctuations in the level of income, and consumer demand was considerable. Therefore, Clark (1917, 1932) focused on making a future prediction for consumer demand effect

[3] The accelerator theory is called as Capacity Utilization theory by Kuh (1963) and Chamberlain et al. (1989).

on the supply of producer in the crisis time in a specific area, rather than exploring a microeconomic approach to firm-level investment behavior. According to Clark's inference, the acceleration principle states that net investment is directly proportional to the time increase in consumption, the factor of proportionality is the amount of equipment necessary to produce one unit of consumers' goods.

Following Clark (1917), P. Samuelson (1939a, 1939b) applied the interaction of the Keynesian multiplier and Clark's acceleration principles into the business cycle, which is called the multiplier-accelerator model. The theory was developed at the macroeconomic level. The model derived by the assumption of Hansen (1939), where he developed a new model sequence that combines the multiplier analysis with the acceleration principle (P. A. Samuelson, 1988). This modification is done by adding governmental deficit spending, private consumption expenditure induced by previous public expend, and induced private investment.

Refer to principles of accelerator theory of investment behavior; the desired capital is proportional to output which is equal to constant, μ:

$$\frac{K_t^*}{Y_t} = \mu \qquad (2.2)$$

Which can be re-written as:

$$K_t^* = \mu Y_t \qquad (2.3)$$

The process called simple accelerator where the rate of growth of the capital stock is equal to the exogenous rate of growth of demand; if factor costs are constant, then both the price of output and the capital-labor ratio are constant (Nickell, 1978). In other words, in a simple accelerator model, the actual capital stock $\mathrm{K_t}$ adjusts instantaneously to the desired capital stock, $\mathrm{K_t} =, \mathrm{K_t^*}$. It follows that net investment, $\mathrm{I_{nt}}$ which is the increase in the actual capital stock can be specified as:

$$I_{nt} = K_t - K_{t-1} = K_t^* - K_{t-1}^* = \mu(Y_t - Y_{t-1}) \qquad (2.4)$$

Equation (2.4) demonstrates the link between investment and changes in output, which expresses that change in output might lead to an accelerated change in investment. The model assumes that a complete and instantaneous adjustment of the capital stock.

As being the earliest model, the accelerator theory was exposed to may criticism by scholars (Chenery, 1952; Koyck, 1954; Tinbergen, 1938) who developed the flexible accelerator model. The first criticism was the model restricted by the unrealistic assumption of instantaneous adjustment of the capital stock. Second, econometric results show that the estimated value of the parameter μ is much smaller than the observed ratio of capital stock to output. The third criticism was that in a simple accelerator model, capital equipment prices, wages, taxes, interest rates were ignored (Baddeley, 2002).

In response to the drawbacks of the accelerator model, a flexible accelerator model formulated by Goodwin (1948) and Chenery (1952) and Goodwin (1948) developed fundamentals of flexible accelerator model, which showed that the desired capital stock fluctuates over a number of years. Chenery (1952) added reaction lags in the capital stock. These lags show the gap between changes in demand and new investment activity. These lags can capture the delays between investment decisions and investment expenditures.

In this model, the firm assumed to have the desired level of capital, determined by long-run considerations. The actual level of capital in period t was denoted by K_t and the desired level by K_t^*, capital is adjusted toward its desired level by a certain proportion of the discrepancy between desired and actual capital in each period, which is formulated as follows:

$$K_t - K_{t-1} = \lambda(K_t^* - K_{t-1}) \qquad (2.5)$$

Where 0< $\lambda < 1$ is a parameter. This equation is from Koyck (1954) distribution lag function.

To obtain investment function, the investment variable needs to be added to the function, which states that changes in the stock capital level equal gross investment less depreciation:

$$K_t - K_{t-1} \equiv I_t - \delta K_{t-1} \qquad (2.6)$$

Where I_t is the gross investment, and δ is the depreciation rate. Equating the right-hand side of above formulations:

$$I_t = \lambda(K_t^* - K_{t-1}) + \delta K_{t-1} \qquad (2.7)$$

Substitute K_t^* from (2.3), into (2.7):

$$I_t = \lambda\mu Y_t + (\delta - \lambda)K_{t-1} \qquad (2.8)$$

The investment equation does not have the intercept term, and the model can be estimated, since there are only two independents, if δ is known. A solution to this problem is to rearrange the equation (2.8) to obtain:

$$I_t = \lambda\mu Y_t - (1 - \delta)\lambda\mu Y_t + (1 - \lambda)I_{t-1} \qquad (2.9)$$

The investment equation (2.8) and (2.9) represent the flexible accelerator investment model. The main difference between the simple accelerator model and flexible accelerator model is flexible accelerator includes lags in capital stock, which avoids the unrealistic assumption of instantaneous adjustment of the capital stock and corresponds to the dynamic structure of the investment.

2.3.3 Expected Profit Theory

Expected profits theory emerged to the subsidiary hypothesis under the accelerator theory (Tsiang, 1951). The major contributions to profit theory were made by Tinbergen (1939), Kalecki (1949), L. Klein (1951), and Grunfeld (1960). In the expected profit model, it was contended that the investment decisions are made by considering the present value of expected future profits since present profits are most likely to reflect future profits (Kuh, 1963). Tinbergen (1939) has announced the main concept of profit theory as:

"There is fairly good evidence that the fluctuations in investment activity are in the main determined by the fluctuations in profits earned in the industry as a wholesome months earlier" (Tinbergen, 1939, p. 49). However, the expected profit model later criticized by Grunfeld (1960), he added current profit into a flexible accelerator model and found out that the partial correlation of profits and investment was insignificant. Aftermath, the author stated that their results did not confirm that profits are a good measure of expected profits that will tend to lead investment expenditures. He added that; "*The observed simple correlation between investment and profits seems to be since profits are just another measure of the capital stock of the firm and one that is in most cases inferior to the measure that we have constructed*." (Grunfeld, 1960, p. 219). Furthermore, Grunfeld (1960) suggested that discounted future earnings less the costs of future additions to capital provides a better measure of expected profits than current realized profits. In Grunfeld (1960)'s theory desired capital is proportional to the market value of the firm in the securities market, the equation (2.10) formulates the given assumption:

$$K_t^* = \alpha_1 + \alpha_2 V_t \qquad (2.10)$$

Where V_t is the firm's market value, α_1 and α_2 are parameters. Combining (2.10) into the distribution lag function (2.7), then following equation produced:

$$I_t = \beta_1 + \beta_2 V_t + \beta_3 K_{t-1} \qquad (2.11a)$$

$$\beta_1 = \lambda\alpha_1; \;\; \beta_2 = \lambda\alpha_2; \; \beta_3 = \delta - \lambda \quad (2.11b)$$

The main advantages of the theory are that it recognizes the role of expected profit in the investment decision. Besides, the market value of the firm was measured as the market value of stocks outstanding, plus the book value of debt, including short term liabilities. The expected profit theory is the first model used market value of the firm in analyzing the investment behaviour, which inspired to create Q theory. However, the model ignores the crucial financial market factors, such as the cost of funds and information asymmetry. As an early developed theory and considering the immature financial markets, it is very prevalent and acceptable to ignore some crucial financial market determinants.

2.3.4 Liquidity Theory

The liquidity theory was alternatively developed to criticize the accelerator investment theory and expected profit model. The theory was discussed by Meyer et al. (1957), Anderson (1964), Kuh (1963), and Meyer et al. (1964). The main argument in liquidity theory is that cash flow will dominate the level of investment (Kuh, 1963), and the supply of funds schedule rises sharply at the point where internal funds are exhausted (Jorgenson et al., 1968).

Grunfeld (1960) and Kuh (1963) both asserted that current realized profits could not adequately represent profit expectations. Also, Kuh (1963) stated that: "*It seems that the expectational hypothesis for-profits cannot, and perhaps should not, be distinguished from the sales level or capacity accelerator hypothesis. The main candidate variable for the expectational hypothesis is simply net income after tax, a secondary candidate being gross operating profit. Both variables will have strong correlations with the level of sales*." (Kuh, 1963, p. 208).

In the liquidity theory of investment behaviour, desired capital is proportional to liquidity,

$$K_t^* = \alpha L_t \qquad (2.12)$$

Where α is the desired ratio of capital to the flow of internal funds available for investment. In equation (2.12) demonstrated the simple expression of liquidity theory of investment based on Jorgenson et al. (1968)'s study. The other expression of the liquidity theory of investment behaviour with the intercept term α_1 is indicated below:

$$K_t^* = \alpha_1 + \alpha_2 FC_t \qquad (2.13)$$

Where FC_t is the cash flow variable, and α_1 and α_2 are parameters.

To obtain the investment function, V_t in equation (2.11a), expected profit model, can be replaced by FC_t. Equation (2.14) as below:

$$I_t = \beta_1 + \beta_2 FC_t + \beta_3 K_{t-1} \qquad (2.14)$$

The cash flow- liquidity model, represents both the firm's internal funds and profit levels (Kuh, 1963). Therefore, the model is not an alternative model of the expected profit model; it might be accepted as augmenting the model by incorporating the cost of investment funds.

As the main drawbacks identified in an expected profit model, the same reasoning is still valid in liquidity theory which holds some constraints such as transaction costs in financial markets and essential factors such as interest rates, the price of equipment and machines are ignored.

2.3.5 Neoclassical Theory

The neoclassical theory of investment theory is based on optimal capital accumulation (Jorgenson et al., 1968), which is extensively studied by Jorgenson (1963, 1967, 1971). The investment theory is derived by the assumption, which is capital accumulation, to be based on the objective of maximizing the utility of a stream of consumption. The main principle of theory, optimal capital accumulation, meets the primary objective, which is: "*The firm maximizes the utility of a consumption stream subject to a production function relating the flow of output to flows of labor and capital services.*"(Jorgenson, 1967, p.

136). Different from than accelerator theory, neoclassical theory investment theory includes a theory of cost of capital, which was developed by Miller et al. (1961) and Miller et al. (1966).

The neoclassical investment theory provides a more precise approach to investment behavior based on the net worth maximization of firms. Net worth is defined as the integral of discounted net revenues includes the interest rate. Also, net revenue is defined as current revenues less expenditure on both current and capital account, including taxes (Jorgenson, 1963). Net worth, W, of the firm is defined as the net present value of its cash flow over time *t* and worth of firm before tax is formulated as follow:

$$W = \int_0^{\infty} e^{-rt} \, [R(t) - D(t)] dt \qquad (2.15)$$

Where, r is the interest rate, $R(t)$ is revenue before tax and $D(t)$ is the direct tax.

As Jorgenson (1967) provided, the present value is maximized subject to two constraints. Firstly, the rate of change of the flow of capital services is proportional to the flow of net investment. The constant of proportionality may be interpreted as the time rate of utilization of capital stock, that is, the number of units of capital service per unit of capital stock. Assumed that capital stock is fully utilized so that this constant may be taken to be unity. Net investment is equal to total investment less replacement. There is a connection between the capital stock K(t) and the rate of investment I(t), which takes the form as:

$$\dot{K}(t) = I(t) - \delta K(t) \qquad (2.16)$$

This states that the rate of change of the capital stock, $\dot{K}(t)$, is equal to the purchase of new capital, $I(t)$, less the amount of capital depreciation, $\delta K(t)$. Secondly, levels of output and levels of labour and capital services are constrained by a production function:

$$F(Q, L, K) = 0 \qquad (2.17)$$

Revenue before tax, $R(t)$, and direct tax, $D(t)$, are defined as follows:

$$R(t) = pF[K(t), L(t)] - sL - qI \qquad (2.18)$$

Where p is output price, $F[K(t), L(t)]$ is output quantity, s is the wage rate, L is labour quantity, and q is the price of capital equipment.

$$D(t) = u(pF[K(t), L(t)] - sL - (v\delta q + wrq - x\Delta q)K] \qquad (2.19)$$

Where *u* is income tax rate, *v* is the proportion of replacement chargeable against income for tax purposes, *w* the proportion of interest payment chargeable against income for tax purposes, x is the proportion of capital loss chargeable against income for tax purposes and lastly to reminder K is capital stock and the rate of replacement, direct taxes.

Under certain simplifying assumptions, the corresponding conditions concerning the optimal levels of labor and capital are:

$$\frac{\partial(K(t), L(t)}{\partial L^*} = \frac{s}{p} \qquad (2.20)$$

$$\frac{\partial(K(t), L(t)}{\partial K^*} = \frac{c}{p} \qquad (2.21)$$

Where Jorgenson (1963) called c as “the user cost of capital”, the "shadow" price or implicit rental of one unit of capital service per period, which is defined as:

$$c = q\left(\frac{1-uv}{1-u}\delta + \frac{1-uw}{1-u}r - \frac{1-ux}{1-u}\frac{\Delta q}{q}\right) \qquad (2.22)$$

Jorgenson et al. (1968) divided the neoclassical investment theory into two phases as Neoclassical I and Neoclassical II, where they emphasized the transitory term in which temporary or short-term effects can be omitted from the equation. Expressly, they referred to the theory of investment behavior incorporating capital gains as Neoclassical I and the theory excluding capital gains as Neoclassical II is regarded as "transitory". This leads them to rearrange the user cost of capital of Neoclassical II as below:

$$c = q\left(\frac{1-uv}{1-u}\delta + \frac{1-uw}{1-u}r\right) \qquad (2.23)$$

To obtain the equation for desired capital stock, the production function is Cobb-Douglas with the elasticity of output concerning capital, γ, is:

$$\gamma = \frac{\partial F(K(t),L(t))}{\partial K}\frac{K^*}{F(K(t),L(t))} = \frac{c}{p}\frac{K^*}{F(K(t),L(t))} \qquad (2.24)$$

It follows that,

$$K^* = \gamma\frac{pF(K(t),L(t))}{c} \qquad (2.25)$$

Equation (2.25) states that the optimal level of capital stock as an increasing function of output revenue, *PF,* and elasticity, γ, and as a decreasing function of the user cost of capital, *c,* specified in above equations (2.21) and (2.22). Also, the alternative investment function can be produced by combining the equation (2.7) and (2.25). Beside using Koyck distributed lag function in (2.7), Jorgenson (1963, 1967) suggested a more general form of lag distribution:

$$I_t = \sum_{\tau=0}^{\infty} w_\tau\left(K^*_{t-\tau} - K^*_{t-\tau-1}\right) + \delta K_{t-1} \qquad (2.26)$$

Where w_τ represents the weight of lag distribution for the period τ. Equation (2.26) implies that investment is the sum of an infinite series of fractions of changes in the desired level of capital stock. Also, Jorgenson et al. (1968, p. 689) used the following specific form of weight distribution:

$$I_t = w_0(K_t^* - K_{t-1}^*) + w_1(K_{t-1}^* - K_{t-2}^*) - \alpha_1(I_{t-1} - \delta K_{t-2}) + \delta K_{t-1}$$

(2.27)

To obtain a neoclassical investment function, K^* from equation (2.25) to be added into equation (2.22) by following Jorgenson et al. (1968), then the following equation is produced:

$$I_t = \beta + \gamma w_0 \left(\frac{p_t F_t}{c_t} - \frac{p_{t-1} F_{t-1}}{c_{t-1}}\right) + \gamma w_1 \left(\frac{p_{t-1} F_{t-1}}{c_{t-1}} - \frac{p_{t-2} F_{t-2}}{c_{t-2}}\right) - \alpha_1(I_{t-1} - \delta K_{t-2}) +$$

$$\delta K_{t-1}, \text{ (2.28)}$$

Compared to previous models, the neoclassical model has many advantages. First, the net worth maximization model defines the link between investment and expected profits of firms. Second, the neoclassical theory of investment primarily identified the user cost of capital, which was not considered in previous models. Also, the user cost of capital concepts has inspired the Q model to include adjustment cost function. Lastly, the neoclassical model consists of many other variables such as tax, interest rate, output level; therefore, it is easier to measure their impact on investment.

On the other hand, the model is subject to criticisms. First, output still has a strong effect as a determinant of investment, compared to the user cost of capital, which has a modest impact on investment function (Chirinko, 1993). Second, although the investment decision process is considered as dynamic instead of being static and Jorgenson (1971) attempted to modify the neoclassical model subject to dynamic optimization, the first-order conditions used to derive the optimal level of capital stock stayed static (Kuh, 1963).

In the literature, the neoclassical investment theory has been widely applied to various industries. Jorgenson et al. (1968) applied the investment theories on 15 manufacturing firms, including General Motors, General Electric, and DuPont. They were able to compare different investment theories and provided the best fit theory into the industry. Based on their empirical research, the neoclassical model is more likely to produce the best outcome according to the criterion of the minimum standard error for the fitted distributed lag functions. In addition to the seminal paper of Jorgenson et al. (1968), where they widely compared four different investment theories, Kopcke (1977, 1982, 1985) had a critical comparison of investment theories, including the accelerator theory, cash flow, neoclassical and Q theory. Although the author tried to obtain a definite conclusion about the performance of the investment theories based on three criteria, estimation, static forecast, dynamic forecast ability of each model, the studies could not draw a precise result because of limitation in data sets.

2.3.6 Q Theory of Investment

Q theory of investment is the one which is derived by Brainard et al. (1968) and Tobin (1969, 1978) to address the pitfalls of the Neoclassical theory of investment. The theory stands out with a couple of distinctive features: firstly, the theory considers the cost of the adjustment process of investment, add some more here. Secondly, the theory attracts the attention of scholars with high explanatory power in the empirical analyses. Therefore, the modified model is widely applied by scholars to several different industries, such as the airline industry (Li et al., 2004), the housing market (Skjeggedal, 2012), the finance and banking industry (Chung et al., 1994).

Q theory is further evaluated in the following three sub-sections: While the first section, *Foundation of Tobin Q*, mostly delivers theoretical developments of the model, the second section, *Application of Tobin Q*, provides current literature on the adaptation of

Q variable to various industries, and the last section modification of Q model provides how to adapt the model in the shipping industry.

2.3.6.1 Foundation of Q Theory of Investment

The roots of the Q model go back to Keynes (1936), as he stated that: "*There is no sense in building up a new enterprise at a cost greater than that at which a similar existing enterprise can be purchased; whilst there is an inducement to spend on a new project what may seem an extravagant sum*." (Keynes, 1936, p. 151). The model proposed that investment expenditures are positively related to average Q, which has defined as the ratio of the financial value of the firm to the replacement cost of its existing capital stock (Chirinko, 1993).

Q model emerged to address two fundamental problems of neoclassical theory and the accelerator theory of investment. The first problem was the capital adjustment process; in other words, the adjustment cost, which is associated with the sale, purchase, or productive implementation of capital goods, was accepted instantaneous and complete each period in the previous investment theories (Nickell, 1978). In the neoclassical model and Q model, the adjustment cost is described as a strictly convex function, as given in Figure 2.1 (Abel, 2015). The adjustment costs increase with the rate of investment or disinvestment, and the costs reach zero levels only when the investment is zero, as it is shown in Figure 2.1. The convex adjustment cost was initially proposed by Jorgenson (1963), Eisner et al. (1963), Lucas Jr (1967), Gould (1968), and Tobin (1969), which was incorporating the convex adjustment cost function into firm value maximization function of the neoclassical model. The second drawback, which was addressed in the Q model, was the role of expectations in future investment opportunities. Brainard et al. (1968) and Tobin (1969) studied this issue and suggested that the investment is made until the market value of assets is equal to the replacement cost of assets (J. E. Eklund, 2010).

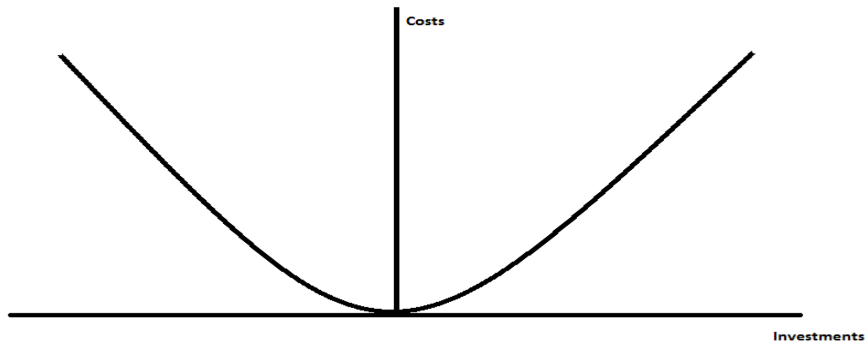


Figure 2.1 Convex Adjustment Cost Function

The central concept is similar to the neoclassical approach is to maximize the net worth of the firm, V_t, which is the sum of its discounted future profits evaluated over an infinite time horizon:

$$V_t = \int_0^\infty e^{-rt}[Y_t - wL_t - G(I_t) - qI_t]dt \qquad (2.29)$$

w is the wage level,

r is the interest rate,

q is the capital price,

L_t is the labour quantity,

Y_t is revenue, which replaces the term $pF(K_t, L_t, A_t)$ in equation (2.18).

$G(I_t)$ is the adjustment cost function, which is assumed to be convex in investment so that the larger the investment amount, the larger the adjustment cost.

$\Pi_t = [Y_t - wL_t - G(I_t) - qI_t]$ is the firm's profit at period t.

In above the dynamic optimization problem, I_t and K_t are control and state variables, respectively. The corresponding Hamiltonian equation for the optimization problem is:

$$H_t = [Y_t - wL_t - G(I_t) - qI_t] + \widetilde{q}_t(I_t - \delta K_t) \qquad (2.30)$$

Where $\widetilde{q_t}$ is the co-state variable or the shadow price of capital, which determines the optimal rate of investment (Hayashi, 1982). The corresponding first order and transversality conditions are:

$$\widetilde{q_t} = q + G_I \quad (2.31a)$$

$$\pi_K = Y_K = r\widetilde{q_t} - \dot{\widetilde{q_t}} \quad (2.31b)$$

$$\lim_{t \to \infty} (e^{-rt} \widetilde{q_t}\, K_t) = 0 \quad (2.31c)$$

It can be shown as follows:

$$\widetilde{q_t} = \int_0^{\infty} e^{-rt} \Pi_K dt = \int_{t=0}^{\infty} e^{rt} Y_K dt = \frac{\partial V_t}{\partial K_t} = V_k \qquad (2.32)$$

The equation (2.32) implies that the shadow price of holding an additional unit of capital, $\widetilde{q_t}$, which is equal to the marginal change of the firm's net worth with respect to capital. Following interpreting the equations, the equation (2.31a) shows that the shadow price of capital should equal the market unit price of capital plus the marginal cost of adjustment along the optimal path. Furthermore, the equation (2.31b) states that an incremental change in profit due to one additional unit of capital should be equal to the interest from holding it, $r\widetilde{q_t}$, less the change in the shadow price of capital, $\dot{\widetilde{q_t}}$. Also, the equation (2.31c) states that as the time period approaches infinity, the value of capital stock held by the firm must approach zero. If this condition failed, or the firm could not hold its capital forever, it would be able to increase its market value (or net worth) by selling out the capital stock, and therefore the firm's net worth could not be maximized.

To get investment equation, the adjustment cost function, $G(I_t)$ needs to be specified. For practical purposes, the following quadratic adjustment cost function is assumed:

$$G(I_t) = \frac{a}{2} I_t^2 \qquad (2.33)$$

where a is a constant, which must be positive for the adjustment cost to be convex in I_t, Combining 2.28 and 2.26a gives, to remind equation 2.26a is provided below:

$$\widetilde{q_t} = q + G_I \qquad (2.31a)$$

$$I_t = \frac{1}{a}[\widetilde{q_t} - q] \qquad (2.34)$$

It has several important implications. First, it explains the link between a firm's investment and its marginal net worth or market value with respect to the capital stock, $\widetilde{q_t}$, the shadow price of capital and the unit replacement cost of capital, q. In particular, q summarizes all information regarding future investment decisions of firms. The q value captures the effect of an additional dollar of capital on the present value of profits. Therefore, the firm decides to increase the capital stock if q is high and reduce the capital stock if q is low (Romer, 2006). The expression (2.34) implies that the firm will invest, I_t>0, if the shadow price is larger than the replacement unit cost of capital, $\widetilde{q_t}$>q. Alternatively, the firm will disinvest, I_t <0, if $\widetilde{q_t}$<q and $I_t = 0$ if $\widetilde{q_t}$=q.

Second, since the coefficient a in equation (2.34) is different from zero, the investment cannot reach an infinite rate, which means capital stock cannot adjust instantaneously, but only gradually, to its new level.

Third, equation (2.34) implies the following equation, which can be estimated empirically:

$$I_t = \beta[Q_t - 1] + u_t \qquad (2.35a)$$

$$Q_t \equiv \left(\frac{\tilde{q}}{q}\right)_t \qquad (2.35b)$$

where $\beta = 1/\alpha$, u_t is an error term, and Q is called "marginal Q", which equals the ratio of the shadow price to the replacement unit cost of capital.

If the adjustment cost function has the following form:

$$G(I_t) = \frac{a}{2}\frac{I_t^2}{K_t} \qquad (2.36)$$

Then the investment equation (2.35) becomes:

$$\left(\frac{I}{K}\right)_t = \beta[Q_t - 1] + u_t \qquad (2.37)$$

The difference between the equation (2.35) and (2.37) is that the dependent variable is the latter is expressed in relative terms, as a ratio to the capital stock, $(I/K)_t$. The equation (2.37) is especially useful for the empirical study of investment at the firm-level since the use of the dependent variable in a relative form helps reduce heterogeneity across firms. However, this specification may not be consistent with the dynamic optimization theory and is not useful for empirical study at an aggregate level.

The investment equation (2.35) and (2.37) are ready for empirical estimation, except the shadow price variable, the marginal Q variable, is unobservable, and therefore its data are not available. To solve it, Tobin (1969) replaces the marginal Q variable with the average Q, which is the ratio of the firm's market value to its replacement cost, which is illustrated in equation (2.38):

$$Q = \frac{Market\ Value\ of\ Firm\ Capital}{Replacement\ Cost\ of\ Capital} \qquad (2.38)$$

The Q model has been exposed to some critiques. The first issue has arisen from the using average Q in place of marginal Q since investment regression is likely to suffer from misspecification by using average in place of marginal. Hayashi (1982) worked on this arising problem and stated that marginal Q and average Q is identically equal, $q_m = Q_a = 1$, if the firm is a price taker (perfect competition), and their production and installation functions are linear homogeneous. If this condition is violated, then the investment equation is likely to be biased. Second, the imperfection of financial markets may lead to bias in using the average Q instead of marginal Q (Chirinko, 1993). Third, it is not easy to compute the actual replacement cost of capital because of different depreciation methods and tax policies. Forth, due to the correlation between Q ratio and many other variables, the extension of the model in empirical research is often subject to the multicollinearity problem. Various modifications have solved the listed problems arising towards the Q model of investment.

Furthermore, in the literature, the Q variable is further investigated, and some scholars have questioned its function. Abel et al. (1994) further worked on the unified Q theory of investment with neoclassical theory settings. They contributed to the adjustment-cost framework under uncertainty in association with fixed costs of investment. More recently, Bolton et al. (2011) applied a unified theory of Tobin's q to demonstrate the impact of external financing costs on the firm's optimal investment level, financing, and risk management.

2.3.6.2 Application of Q Theory of Investment in Various Industries

Q theory of investment widely applied to various industries by modifying the Q variable. Each research paper utilized different calculation methods based on the features of the industry and data availabilities. The application of the Tobin Q model of investment is grouped under three main categories: the first one is, which widely adopted an approach in the literature, modifying either average or marginal Q variable to measure ownership structure and investment performance. The second group is to measure the Q variable as a financial performance measure and the explanatory power of the Q variable as an investment model. The third group is the one rarely applied is to modifying the Q variable to measure investment level and asset price valuation link.

Measuring ownership structure and investment performance goes back to Berle et al. (1932), and Morck et al. (1988) researched to investigate the relationship between board ownership and market valuation of the firm by Tobin's Q model in 1980 for 371 firms of Fortune 500. To measure performance, they used average Tobin's Q, equal to the ratio of the firm's market value to the replacement cost of its physical assets. Tobin's Q is high when the firm has valuable intangible assets in addition to physical capital, such as monopoly power (Lindenberg et al., 1981), goodwill, a stock of patents, or good managers. The numerator of Q is the firm's market value, defined as the sum of the actual market value of common stock and estimated market values of preferred stock and debt. The denominator of Q is the replacement cost of the firm's plant and inventories. They found a highly volatile relationship between ownership of board members and market valuation of the firm based on the Q model. Himmelberg et al. (1999) also examined the managerial ownership and the link between ownership and financial performance of the firm by applying a Q model from 1982 to 1984 for 600 firms. More recently, Gugler et al. (2003) compared the significance of average Q and marginal Q in measuring ownership structure and investment performance for 3673 firms from 1989 to 1998. Hall (2001) defined the Q variable as the ratio of the value of ownership claims on the firm, less the book value of inventories, to the replacement cost of equipment and structure.

Q variable as financial performance measure was applied to the airline industry by Li et al. (2004). They analyzed 27 major airline carriers from the Asia Pacific, Europe, and North America, which are publicly listed, the data gathered from 1989 to 1999. The paper different than other Q model utilized research papers applied an alternative Q variable calculation method, which is approximate Q proposed by Chung et al. (1994).

In the literature, the application of either marginal or average Q variable is more common, and approximate Q is rarely adopted. The approximate Q is identified as the ratio of total of firm's share price, outstanding number of common stock shares, liquidating value of the firm's outstanding preferred stock, the value of the firm's short-term liabilities net of its short-term assets, plus the book value of the firm's long term debt to book value of the total assets of the firm. Chung et al. (1994) argued that approximate Q is relatively simple since required inputs are readily obtainable from a firm's primary financial and accounting information. Li et al. (2004) proved that the approximate Q ratio captures additional dimensions of the airline financial performances compared to other financial measures. In this study, the authors overcame the bias problem arising from using the Q model in oligopolistic markets by applying approximate Q.

Moreover, the role of Q theory was also widely questioned by scholars, and its explanatory power in investment relation was accepted poor (Bond et al., 2007; Caballero et al., 1995). However, more recently, Kilponen et al. (2016) studied on the Q theory of investment by the frequency domain on the US data of corporate fixed private non-residential investment in equipment and structures from 1972 to 2007. They reinterpreted Q theory based on Rua (2011)'s study, a wavelet approach to forecasting. In contrast to the literature, they found that the Q model might be better explaining short term relations rather than long term ones by considering the frequency relationship between Q and investment. Moreover, they found that using the wavelet approach and the proxies for Q significantly increases the predictive power of the investment equation. In some research, extended Q model of investment decision is integrated into dynamic risk management analysis with financial tools and showed that when there are no fixed costs of investment, marginal Q is a more accurate measure than average Q for the firm's investment opportunities (Bolton et al., 2011).

Lastly, as an example of the application of the Q model in fixed business investments, Skjeggedal (2012) applied Q theory into Norwegian housing from 1992 to 2011. The value of Norwegian housing, Q, is defined as the ratio of housing prices to the construction costs of new housing, and housing is defined as the aggregate housing stock in Norway's national accounts. The author stated that the value of housing is significantly related to housing investment, according to the Q theory model of housing. In the shipping industry, although the Q model of investment has not been applied, G. Dikos et al. (2003) provided future research recommendations for the application of Q model investments. They proposed that the Q variable can be defined as the ratio of second-hand ship prices to newbuilding prices to stand as a ratio of the market value of the firm to replacement cost. Indeed, their proposal complies with the rationale of the Q variable, considering the features of the Q model and the application in the housing market by Skjeggedal (2012).

Considering the application of the Q model in different industries with different market structures, either competitive market or oligopoly, it is appropriate to state that the Q model is an adjustable model to each market with proper advancements. While Skjeggedal (2012) applied the Q model of investment to the housing industry, which is a competitive market, Li et al. (2004) applied the Q model with an alternative calculation to the airline industry, which is an oligopolistic market. The application of the Q model in various industries showed that the Q model is an adjustable model to utilize in different market structures with considering appropriate adjustment on the original model.

2.3.6.3 Application of Q Theory of Investment in Shipping Industry

Tobin Q model is proposed for application to the shipping industry, provides a methodological improvement, as it is a flexible model that can be utilized in various industries with different market structures (Girgin et al., 2018). Furthermore, the application of Q theory to ship investment modeling allows the incorporation of the dynamic and complex investment structure of tanker and bulker shipping. Following the Tobin Q model, the market value of an individual ship is taken from market data, and the replacement cost is evaluated based on the long-term value of an individual ship calculated by a net income-based approach discounted at an appropriate rate.

The approach utilized in this study compares the calculated long term asset value to the actual value of an asset, which is initially introduced by Marcus et al. (1991) but includes significant improvements. The method applied in Marcus et al. (1991) focuses on the comparison of the estimated ship price by NPV with the actual price of a ship. This comparison is proposed as a guide to investors for tracking investment timing for the highest profitability by utilizing a “buy low and sell high” strategy. However, in the course of calculation of the nominal value of a ship the authors utilise a cost-based value of asset for a 35.000 DWT dry bulk carrier over the period of 1970 to 1984 with the assumption of a constant cash flow throughout the asset life, which leads to bias and overlooks freight market cyclicality and volatility. Although the sample is confined to only one ship type and yard and the estimated cash flow is static, their findings indicated a market bubble for the given period. To incorporate the market conditions in the model suggested that a robust ratio that takes into evaluation the future movement of ship valuation. NPV and second-hand prices of an individual ship are used instead of second-hand ship value and newbuilding prices, respectively. Using the newbuilding price instead of the NPV of a ship would distort the indicator as a decision-making mechanism as newbuilding price is also affected by the factors not related to the market value of an asset at operation (e.g., time lag for construction compared to market conditions, shipyard industry capacity constraints, market conditions in other shipping segments that may increase shipyard capacity utilisation, State subsidization policies, volume order discounts, etc.). On the other hand, using the prospective earnings of an existing ship to its current value accurately follows the theory behind Tobin Q which is the ratio of firm's market value to its replacement cost given that market value for a ship is related to its revenue generation prospects rather than on a negotiated contracted price affected by exogenous parameters not directly connected with its value at the moment of evaluation. Furthermore, the use of newbuilding prices due to the time lag between order and delivery cannot portray current market value which explains the reasons of the second-hand prices reach higher levels than newbuilding prices during the peak level.

The main concept in Tobin Q theory is to evaluate if the firm's value is over-valued or under-valued based on the firm's market value to its replacement cost. The valuation is identified with Q value. If Q value is above 1, then it is a sign of not investment if Q value is lower than 1, then this is a signal for investment. According to this fundamental concept of Q theory, the market value of an individual ship is taken from market data, and the replacement cost is evaluated based on the long-term value of a single ship calculated by a net income-based approach discounted at an appropriate rate, plus the scrap value added at the end of the economic life of the ship.

After provided an extensive theoretical review on the firm-level investment theories with their main features and critiques throughout the 1900s to 1970s, five mainstream firm-level investment theories are summarized with their investment formulation, main features and main critiques in Table 2.1 as follows:

Table 2.1 Summary of Firm-Level Investment Theories

	Accelerator Theory	Profit Theory	Liquidity Theory	Neoclassical Theory	Q Theory
Formulation	$I_{nt} = K_t - K_{t-1} = K_t^* - K_{t-1}^* = \mu(Y_t - Y_{t-1})$	$I_t = \beta_1 + \beta_2 V_t + \beta_3 K_{t-1}$	$I_t = \beta_1 + \beta_2 FC_t + \beta_3 K_{t-1}$	$I_t = \sum_{\tau=0}^{\infty} w_\tau (K_{t-\tau}^* - K_{t-\tau-1}^*) + \delta K_{t-1}$	$\left(\frac{I}{K}\right)_t = \beta[Q_t - 1] + u_t$
Features	The actual capital stock K_t adjusts instantaneously to the desired capital stock, $K_t =, K_t^*$	The investment decisions are made by considering the present value of expected future profits since present profits are most likely to reflect future profits.	The cash flow will dominate the level of investment, and the supply of funds schedule rises sharply at the point where internal funds are exhausted.	The theory is based on optimal capital accumulation to be based on the objective of maximizing the utility of a stream of consumption.	The investment is made until the market value of assets is equal to the replacement cost of assets. The main concept is similar to the neoclassical approach is to maximize the net worth of the firm.
Critiques	-Restricted by the unrealistic assumption of instantaneous adjustment of the capital stock. -Capital equipment prices, wages, taxes, interest rates were ignored.	The model ignores the crucial financial market factors, such as the cost of funds and information asymmetry.	Transaction costs in financial markets, interest rates, the price of equipment, and machines are ignored.	The output has still strong effect as a determinant of investment The investment decision process is considered dynamic instead of being static.	The imperfection of financial markets may lead to bias in using average q instead of marginal q. Computing the actual replacement cost of capital

2.4 Empirical Studies on Dry Bulk and Tanker Ship Investments

Empirical studies on ship investments and the predictability of the investment timing considering the market prices are relatively scarce, and still, ship valuation studies are considerably limited in the literature (Karlis et al., 2019). Moreover, the researches on investment timing and strategies are indicating a significant gap in the literature. Karlis et al. (2019) stated that there are only eight papers on investment timing, and investment strategies are found in the shipping literature published in Science-Direct[4] from 2000 to 2017. Moreover, among freight market studies, the tanker market is the least researched field compared to dry bulk and container markets. In light of this information, the literature reviewed to reveal the studies related to the dry bulk and tanker ship investments, strategic investment decisions, and investment timing.

2.4.1 Dry Bulk Ship Investments

In dry bulk ship investment literature, P. Marlow (1991a)'s study raised attention on the level of ship investments and incentives. He conducted an empirical research series (P. B. Marlow, 1991b, 1991c) to analyze the maritime industry in terms of the relationship between industry incentives and investment levels for the UK shipping industry. In the research series, besides providing a robust theoretical background for the shipping industry incentives and investment level, the empirical model has been tested by several modified variables to obtain the best output. Unfortunately, the model did not produce the expected outcome of a positive link between incentives and investment levels. This rather contradictory result may be due to running the analysis for all type of vessels, which is likely to lead bias in the sample, and further data collection might be required to determine precisely how incentives affect investment levels.

[4] Data is downloaded in 01/10/2018, https://www.sciencedirect.com/

The studies after the 1990s are more likely to analyze the ship investment decision-making processes, for example, G. Dikos et al. (2003) analyzed the second-hand ship valuation by using newbuilding prices and charter rates on dry bulk shipping market throughout 1976 and 2002. They developed the model based on the real options approach[5] to analyzing shipping investment decisions and applied a structural partial equilibrium framework to examine the prices of second-hand vessels through the prices of new vessels and the charter rates. The empirical results stated that the hidden asset play value in the prices of second-hand vessels had been empirically proven within the developed model. The study of Tsolakis et al. (2003) is in line with G. Dikos et al. (2003), examined the second-hand ship prices for the tanker and dry bulk markets from 1960 to 2001. They analyzed the price valuation by Error Correction Model. The model consists of comparatively comprehensive variables, such as the newbuilding price, the interest rates, time charter rate. Their main finding is that second-hand prices in different types of ships react differently to the underlying fundamental factors; in particular, newbuilding prices have a higher effect on the determination of second-hand prices than time charter rates.

Choosing the right time to invest can be a vital step for each industry to take advantage of market fluctuations. Notably, in the shipping industry as a highly capital intensive industry, timing is a central concept to increase return and control the risk. Alizadeh et al. (2007)[6] used the price-earnings ratio to investigate investment decisions in the sale and purchase market for dry bulk ships from 1976 to 2004. They proposed a co-integration approach for timing investment and divestment decisions in shipping markets.

[5] Real option approach is developed by Real Option Theory which is provided in Section 2.4.1 Fundamental Approaches to Investment Theories

[6] Alizadeh et al. (2007) applied the same approach from their previous study of Alizadeh et al. (2006) which was analysed Tanker market into Dry Bulk Market.

The proposed model, second-hand ship price-earnings (P/E) ratio, was developed as a substitute approach to the usage of the Efficient Market Hypothesis in the shipping industry. Their findings supported that the relationship between second-hand ship price and earnings may guide the future behavior of ship price, which can be used for investment timing in shipping markets.

Furthermore, their study has a guidance role in advising market participants with an alternative investment decision tool, the price-earnings ratio, which ratio reflects the relative degree of overvaluation or undervaluation in asset prices. Gkochari (2015) had also recently studied the investment timing in the dry bulk shipping market by applying the combined methods of option pricing (Real Option Analysis) and game theory, called the combination as an option games approach, which has been initially introduced in this paper. Dai et al. (2015) analyzed volatility spillover effects across the newbuilding and second-hand vessel markets and freight market of dry bulk shipping by applying a tri-variate GARCH model from 2001 to 2012. Although the study is not directly considering ship investments, it has developed a robust argument on newbuilding and second-hand ship price fluctuations and their relationship with freight rates. Therefore, their study has some distinctive contributions to the literature, since it has mainly examined the relationship among the freight rate volatility, newbuilding and second-hand vessel price volatility which has been widely ignored in the mainstream of research. Their results provided several valuable contributions in terms of second-hand, newbuilding, and freight market. First, they found that the volatility spillovers from the second-hand market to the freight market are dominant, and similarly, the direction of the volatility is from the new building to the second-hand market gets stronger. Second, they found unidirectional transmission effects between freight market and newbuilding market that volatility transferred from freight market to newbuilding market, but not vice versa. Their findings are partially against the conventional assumption in the shipping industry, which is believed that the demand drives the supply. Several critiques can be made about the empirical analysis run for 2001 and 2012. During the given time frame, the bulk shipping industry had peak level in vessel prices both in newbuilding and second-hand market and had peak level in freight rates; and right after 2008 Global Financial Crisis (GFC), had very sharp decrease in all the markets and the economy (Celik Girgin et al., 2017). This might have led to having empirical outputs against the conventional approach in the shipping industry since GFC had been distorted the market and the freight rate could not reflect the real demand status, or even, in turn, the freight rate volatility could be determined by the instant second-hand vessel transaction price volatility.

The strategic investment decision process in the dry bulk carrier has been recently studied with a model, Real Option Analysis. Dixit et al. (1994) initially introduced the model to the shipping industry. The ROA model contributed to the understanding of boom-and-bust cycles in the shipping industry, which is mainly caused by construction cascades, and recession-induced construction booms are the time-to-build delay. The author used the log P/E ratio to test its role in informing investors of the future of the market. She found that the log P/E holds guiding characteristics during market fluctuations, and the movement of this ratio can be accepted as a signal for a new investment decision.

Moreover, real option analysis was evaluated in an extended approach by Bendall et al. (2007) for maritime investment strategies. They analysed the flexibility of shipowners to exchange one risky income stream with another option. They proposed an investment scenario of a new container service investment between New Zealand and Australia and compared static and flexible investment strategies. Their results showed that the more options present, then the more value created. More recently, Luo et al. (2018) analysed the ship investment decisions by comparing NPV and ROA. They identified the trigger freight rate to reveal the best investment timing following NPV and ROA results, and they theoretically and empirically proved that ROA provides flexibilities by considering uncertainties in the shipping market, therefore, the model can be accepted as an alternative to NPV approach in investment decision management.

2.4.2 Tanker Ship Investments

In tanker ship investment literature, the amount of research conducted until now is confined to the data availability and access to market practices, which is low due to the market's organisation is limited (Karlis et al., 2019). The literature is limited, but there are some seminal studies on ship investment decisions. Alizadeh et al. (2006) analyzed buy and sell trading strategies for the tanker vessel based on their size from 1976 to 2004. This study is the preliminary work of Alizadeh et al. (2007). In both studies, the earnings-price ratio used to investigate investment decisions in the sale and purchase market. Their findings indicated that the relationship between price and earnings in shipping markets contains essential information about the future behaviour of ship prices. The volatility in larger vessel prices is higher than smaller vessels in tanker carrier, which provides an excellent opportunity for asset players to benefit from the buy and sell options.

Moreover, Merikas et al. (2008) had a distinctive study in the tanker market, in which paper, they introduced a variable of the ratio of second-hand price over the newbuilding price (SH/NB) as a useful decision-making tool in the tanker market for the years 1995 to 2006. The ratio initially proposed by Tsolakis et al. (2003), which is attributed to the Q model. They used SH/NP ratio as a dependent variable to analyze the relationship between the main shipping markets and to compare this relationship within a different type of vessel in the tanker industry. This study plays a vital role in directly addressing the issue of investing in the shipping industry, instead merely looking into the relationship between ship as a real asset and its demand in the market. They analyzed the cointegration relationship between the ratio of SH/NP with freight rate, international trade, shipbuilding cost, market risk (freight rate volatility), crude oil price, and interest rate through the Error Correction Model. They found that in a booming freight market, a shipowner needs to purchase a modern second-hand vessel to capitalize on the strong freight market. When the freight market drops, the shipowner should order new vessels, due to the optimism regarding the recovery of the market in the future.

As a strategic ship investment approach, ROA has recently applied to the Suezmax tanker by Pires et al. (2012). They considered the abandonment option of the ship throughout the life of the ship rather than considering operating the ship for the end of the ship's life, and changing the scenario adversely affected the initial investment decision with the ROA method. Moreover, G. N. Dikos et al. (2012) tested the real option hypothesis to investigate the optimal level to invest in the oil tanker shipping market. Their study different than mainstream literature is conducted at the industry-level. They used “wait to invest” option value as an explanatory measure of the investment decision process, and results showed that their model worked statistically significant. Considering ROA in oil tanker investment decision process with the option to wait would create value in whole investment flow.

Overall, the empirical studies on ship investments and related studies on dry bulk and tanker markets have been reviewed to highlight the existing research and the gap in the literature. Some studies have shown the beneficial effects of considering the role of the second-hand market while investing and reconsidering investment timing in accordance with buy low sell high strategy. To date, many unrevealed facets still exist about the relationship between asset valuation and investment timing in dry bulk and tanker markets.

After reviewing the literature on dry bulk and tanker shipping, on the following page, the summary of selected empirical research has provided to demonstrate an overview of the studies in Table 2.2 Literature Review Summary.

2.5 Theory of Ship Price: Natural Price versus Market Price

The pricing mechanism is explained by the demand for the services, in response to the increasing demand, then output price will increase (Nickell, 1978). This rule is purely applicable to the theory of ship price. Before the GFC, the belief for increasing demand for international transport due to increasing world trade leads to an enormous price increase in second-hand and newbuilding prices. As a consequence of the continuous increase in freight rate and ship prices, the availability of loans boosted by banks and financial institutions (Lozinskaia et al., 2017). In a growing environment regarding a number of available funds, increasing freight rate and world trade from 2003 to 2008, financial market collapse and its impact on world trade would not be counted for many market participants. However, the signal was apparent, such as doubling ship prices in the short term, enormously increased revenue. These signs remind the possible valuation mismatches between the natural price and market price of an asset; in other words, valuation disparity between the natural price and market price of an asset. This has been a long debating topic from the time of Smith (1776) until now, where he argued that there is a very volatile relationship between a natural price and market price, and it never ends (Foley, 2009). More recently, S. Klein (2003), Andrews (2015), and Fratini et al. (2016) extensively discussed the theory of valuation in the context of natural prices and market prices and its impact on various economic concepts.

Moreover, these two pricing concepts, natural price and market price are determined by Smith (1776). He explained natural price as "*When the price of any commodity is neither more nor less than what is sufficient to pay the rent of the land, the wages of the labour and the profits of the stock employed in raising, preparing, and bringing it to market, according to their natural rates, the commodity is then sold for what may be called its natural price*." (Smith, 1776, p. 73); and market price as: "*The actual price at which any commodity is commonly sold is called its market price. It may either be above, or below, or the same with its natural pric*e" (Smith, 1776, p. 74).

Natural price carries indicative characteristics; the disparity between natural price and the market price creates an opportunity for the asset play mechanism. When the gap between natural price and market price increase, the risk in the market increases. It is most likely known that market price is expected to converge to natural price level according to the classical economist view. However, it is hard to predict the time of price fall without an empirical method. Shocks and crises are part of the free market economy (Sweezy, 2004); investors and market participants need to read market signals to manage their portfolio efficiently. In this context, the SQ indicator is a highly useful tool to evaluate market signals and manage investment timing.

Table 2.2 Literature Review Summary

	Scope and Approach	Dataset/ Sample	Dependent Var.(output)	Independent Var. (input)	Key Findings	Study/ Authors
1	The relationship between incentives and investment levels/ Capacity Utilization Approach	UK Shipping Industry	Investment	Capacity utilization Existing capital stock Change in output Investment incentives Credit arrangements Expectations	Despite the expectation of the positive link between investments and government incentives, the output showed that there is a negative relationship.	P. Marlow (1991a)
2	Second-hand ship prices valuation analysis / Real Option Value Approach	Tanker and Dry Bulk/ Entire world	Second-hand price of a vessel	New Vessel Expenses The ratio of time charter earnings and capital expenses (EBITDA/CAPEX) Time charter rate Depreciation	They provided strong evidence for a time-varying market price of risk. In other words, the hidden asset play value in the prices of second-hand vessels has been empirically proven within the developed model.	G. Dikos et al. (2003)
3	Econometric analysis of second-hand ship prices/ Error Correction Model	Tanker and Dry Bulk/ Entire world	Second-hand price of a vessel	Time charter rate New Building Price Order book/ Fleet Ratio LIBOR (cost of capital)	New building and time charter have a great effect on all determinants of second-hand prices. The cost of capital was found insignificant in the tanker, in bulk, it is significant and negative in the long run	Tsolakis et al. (2003)
4	Analyzing the investment timing and divestment decisions/ The Stationary Bootstrap Approach	Dry Bulk/ Entire world	Investment/ Divestment	Five years old Ship Prices Time charter rates Price to Earnings Ratio	Trading strategies based on price to earnings ratios significantly out-perform buy and hold strategies in the second-hand market for ships, especially in the market for larger vessels, due to higher volatility in these markets.	Alizadeh et al. (2007)

5	Analyzed the nexus between freight rate, new building, second-hand vessel price / The Tri-variate GARCH model	Dry Bulk/ Entire world	The conditional covariances between: -Freight rate and newbuilding market -Freight rate and second-hand market -Newbuilding and second-hand market	Volatility of -Freight rate -Newbuilding price -Second-hand price	Their results prove the existence of significant bilateral and unidirectional interactions among the freight rate market, Newbuilding vessel, and second-hand vessel market.	Dai et al. (2015)
6	Analyzing the investment timing and divestment decisions/ The Stationary Bootstrap Approach	Tanker/ Entire world	Investment/ Divestment (Handysize, Suezmax, VLCC)	Five years old Ship Prices Time charter rates Price to Earnings Ratio	The relationship between price and earnings in shipping markets contains essential information about the future behavior of ship prices. The volatility in larger vessel prices is higher than smaller ones.	Alizadeh et al. (2006)
7	Investment decision modeling new building vs. second-hand/ Error correction model	Tanker/ Entire world	Second-hand Price/ New Building Price	Average time charter rate Number of transactions in the sale and purchase market Cost per gross tonnage The volatility of the freight rate Price of crude oil LIBOR	In a booming freight market, a shipowner needs to buy a second-hand vessel, as it can be capitalized in the strong freight market. When the freight drops, the shipowner should order new vessels, due to the optimism regarding the recovery of the market in the future.	Merikas et al. (2008)

The natural price[7] and market price of the ship asset have been evaluated from a different perspective to be used in the calculation of the SQ indicator. In the real world, finding the natural price is impossible, and it is not a constant value. However, some approximations can converge to natural price as a long-term value carried by the asset. SQ indicator is calculated by mean-reverting assumption and long-run cash flow; in other words, the SQ indicator is an estimated natural price. SQ indicator is estimated as a natural price by reflecting future cash flows assuming mean-reverting ship market (Caporin et al., 2012). The market price of a ship is accepted as the second-hand price of a ship to calculate the SQ indicator.

2.6 Summary

Chapter 2 has contributed to the fundamentals of investment, firm-level investment theories, empirical research on ship investments, and theory of pricing. Section 2.2 has provided a more-in-depth insight into the definition, type, and feature of investment to establish fundamental knowledge on ship investments. Section 2.3 has contributed to the knowledge of major firm-level investment theories: accelerator, expected profit, liquidity, neoclassical, and Q theory of investment. An extensive literature systematically reviewed in this section to analyze the dynamic behavior of investment regarding theoretical context. A theoretical review on five major firm-level investment theories highlighted that most of the investment theories deal with the dynamics of investments by assuming either instantaneous adjustment or distributed lag structure, which is not related to any optimization process. Q model is the only exception which contains all theoretical foundations to allow a study of investment dynamics under the economic

[7] In the rest of the thesis, nominal price is used instead of natural price.

relationship. Section 2.4 systematically reviewed the empirical studies on ship investments in bulk shipping throughout the 1950s until now. Most of the studies in the literature of dry bulk and tanker shipping showed that the application of firm-level investment theories is highly scarce. The general tendency in the literature of dry bulk and tanker shipping is to identify asset price valuation, volatility in the shipping markets, and the correlation between markets. The main reason for firm-level investment theories being absent from mainstream research in the shipping industry might be the attractiveness of maritime economics, ship investments specifically, has most recently increased. The growing body of knowledge on maritime economics might lead to a broader adaptation of economic models into the shipping industry.

Chapter 3 Research Methodology and Data Sources

3.1 Introduction

This chapter aims to introduce data used in this research, including data sources and definitions, and the methodology utilized to calculate the SQ indicator. In particular, Section 3.2 provides the application method of the Tobin Q model to the shipping industry. Section 3.3 explains the SQ indicator calculation method, and Section 3.4 presents the SQ indicator optimization method. Furthermore, Section 3.5 introduces sample data, sample period, and limitations applied to the indicator calculation. Also, the section presents information about the data sources. Section 3.6 introduces variables to be used in the calculation of the SQ indicator. Finally, Section 3.7 concludes the chapter.

3.2 Tobin Q Investment Model Adaptation

The application of Q theory to ship investment allows the incorporation of the dynamic and complex investment structure of tanker and bulker shipping, as the Q model provides flexibility in adapting the original model. Tobin (1978) originally developed a new approach to monetary policies and investigated asset valuation problems for public companies. He stated that “The ratio of market value to replacement cost is a summary measure of one important impact of financial markets on purchases of goods and services, in particular, durable goods” (Tobin, 1978, p. 422) and explained the role of Q value, which is quite extendable for every industry, not confined to stock market solely. In the following period, Q ratio was applied to measure ownership structure and investment performance (Himmelberg et al., 1999; Morck et al., 1988), the financial performance of airline companies (Himmelberg et al., 1999) and housing market prices movements (Skjeggedal, 2012). The literature brings strong evidence to adapt the Q model to the shipping industry.

Initially suggested by the Tobin Q theory, if Q is greater than 1, it is expected to invest more in the capital, since it is worthwhile. In other words, an investment decision is made according to the market valuation, at the point where market valuation exceeds the replacement costs (where Q is greater than 1), then the investment is accepted as worthwhile. Consequently, the increase in real investment will force high Q ratios back down to equilibrium (Mihaljevic, 2013). This cycle puts forward a need to reinterpret the Q indicator move, whether Q is over level 1.00 is an opportunity to invest or below level 1.00, while using it as an asset valuation indicator. Blanchard et al. (1993) worked on the Q ratio to calculate its value by the 1900s for the financial instructions. He found that Q was 1.26 in 1929, right before the Great Depression. This shows that to use the Q indicator as an early warning indicator within the asset management concept. Considering the amendments applied to the Q ratio calculation and interpretation, it is more realistic to interpret the Q indicator as; if Q is greater than 1, then sell the asset and if Q is lower than 1, then buy the asset.

Q model was initially developed for stock market listed companies and applying the Q model to the firm-level data might lead to more precise and robust results, since the specific data set would be utilized for each firm. However, in this research, the sample data was collected based on industry-level data rather than firm-level data due to the low availability of firm-level data. Despite this limitation, applying the SQ indicator to the industry-level study at the first stage would provide a number of benefits: first, the SQ indicator will be tested using a large sample, which will reduce firm-specific volatilities and increase the reliability of the results. Second, the high availability of industry-level data for an extended time frame will provide continuous data set rather than dealing with firm-level data confined to the life of a specific company. Third, more reliable results were obtained from a large industry-level data set, which could be utilized by several different market participants as a market-leading indicator. However, firm-specific data might limit the usage of the indicator to particular market participants.

Adaptation of Q model in the shipping industry was identified as the market value of a particular ship is taken from market data, and the replacement cost is evaluated based on the long-term value of an individual ship calculated by a net income-based approach discounted at an appropriate rate. As it is illustrated in Chapter 2 by equation (2.38):

$$SQ = \frac{Market\ Value\ of\ \ Ship}{Replacement\ Cost\ of\ Ship} \qquad (2.38)$$

Equation (2.38) is adapted as illustrated in equation (3.1):

$$\Phi_Q \ = \frac{SH_{n,t}}{NPV_{n,t}} \qquad (3.1)$$

Where, Φ_Q is a ratio of market price to the nominal price of a ship,

$SH_{n,t}$ is a second-hand price of a n ship at age t,

$NPV_{n,t}$ is a nominal price of a n second-hand ship at age t,

The market value of a firm capital is denoted as the second-hand (SH) prices of the ship, and replacement cost of capital is denoted as the net present value of the ship. In the shipping industry, it is difficult to identify the precise value of a ship in the market. The underlying revenue generation capacity in a ship's lifetime depends on unknown future operations and market developments (Duru, 2018). In the free market conditions, ship prices (realized valuations) are the product of consensus between parties in the first place. Mental accounting behind the visible consensus is probably influenced by optimistic or pessimistic predictions on future market developments. As such, a realized ship price must also be a sort of predictive valuation. Otherwise, it is only blind speculative pricing. Therefore, while identifying the market value and replacement cost of an asset according to the Q model, the SH ship prices are accepted as the market value, and an estimated long-term value of a ship is used as a replacement cost. Therefore, while identifying the market value and replacement cost of an asset according to the Q model, the SH ship prices are accepted as the market value, and an estimated long-term value of a ship is used as a replacement cost.

3.3 Shipping Q Indicator Calculation

The central concept in Tobin Q theory is to evaluate if the firm's value is over-valued or under-valued based on the firm's market value to its replacement cost. In other words, the Tobin Q model of investment works with an indicator for testing the accuracy of market valuation. The overvaluation and undervaluation of the market are detected by the indicator, which is the ratio of a market value of an asset to the replacement cost of an asset. The model was adapted to the shipping industry as a ratio of the market value of a ship to a nominal value of a ship. While identifying the nominal value of a ship, there were two different ways, DCF of the book value of the ship and long-term value of ship (income-based approach). In the original Q theory model, replacement cost is the book value of an asset, in which it is applied to the firm-level analysis (Chung et al., 1994; Hall, 2001; Li et al., 2004). However, in the shipping industry, 'Book Value' may not be a good predictor of the sustainable and long-term value of the asset. For example, a VLCC tanker was priced at $140m in August 2007, which was probably an asset bubble. If it was purchased at $140m in August 2007, its book value was still around $130m in 2009; the market price was $90m in December 2009[8]. Therefore, considering the book value of

[8] Figures are taken from Clarkson Shipping Intelligence Network Time series in 09 November 2017.

a ship might be deceptive for the valuation analysis, and consequently, DCF of the book value of the ship is eliminated. The nominal value of a ship is calculated by the long-term value of a ship, which utilized the income-based approach. Lastly, the market value of a ship is identified by the spot market value of a SH ship.

The basic principle of discounted cash flow analysis is quite straightforward and convenient to utilize in the SQ indicator. For each year in the life of the ship, the anticipated revenue and expenditure were determined. The net cash flow, revenue less expenditure, was reduced using a discount factor (Williams, 1938). This factor converts the net amount into today's terms by reflecting what the money might otherwise have earned, adjusted for risk. In essence, it accounted for the economic fact that an amount of money to be received in the future is worth less than the same amount of money received today. The NPV method was first formalized by Fisher (1907), and it became a widespread industry practice for investment decisions for its simplicity, secure application to the projects, and due to the lack of a more accurate tool (Espinoza et al., 2013) both internally (Rousos et al. (2012), DR Glen (1996), (P. B. Marlow, 1991b)), and externally by various industry extend (Armeanu et al., 2009; Dimitras et al., 2002; Espinoza et al., 2013; Fortin et al., 2007; Johar et al., 2010; Marchioni et al., 2018). The use of the NPV method has evolved over the years, since the traditional version of the NPV method, which accepts future cash flow as certain values over the lifetime of the project, could not satisfy the need to explain the dynamic investment projects. Therefore, the traditional version of NPV method became less preferred method nowadays against the modified version of NPV, which considers uncertainty while computing the cash flow (Gaspars-Wieloch, 2019). Hopp et al. (2004) analysed several valuation methods and stated that extended NPV would be able to capture the accurate value of a project for the industries, which is characterized by high volatility in investment cost. More recently, Yin et al. (2019) compared the traditional way of NPV and found that its reliability is lower than ROA method. Therefore, modified NPV method has been utilized in this thesis, the cash flow analysis of SQ indicators have been designed to cover the dynamic structure of the shipping market by taking into consideration of the 10-years average of the variables.

The computation of SQ is undertaken by calculating yearly cash flow for each vessel segment with the reference year 1990. Assumed that an investor is willing to invest in an individual ship in 1990 and for each vessel type and age (5, 10- and 15- year- old) discounted cash flow is calculated to find out the nominal value of a ship at the year 1990. For each following year, discounted cash flow is calculated consecutively for an individual ship segment. For example, assumed that an investor plans to invest in the year 1990 in a Handysize 5-year-old SH and the data used before 1990. At that point, the ten-year average of time charter rate and scrap values are computed; in this example, from 1980 to 1990, the operational expense is assumed to be the same as the reference year. The SQ indicator is calculated for each year by taking the 10-year average of the TC rate, scrap values, and operational expenses accrued within the same year, which corresponds to the reference value for NPV calculation. The discounted cash flow is calculated for the next 20 years since the economic life of a ship is accepted as 25 years (Stopford, 2009). Scrap value was calculated by the values of the 1990's scrap prices and multiplied by LDT[9]. Eventually, the value of the asset was calculated as the sum of the each of the discounted cash flows plus the discounted residual value, demolition value of the ship in

[9] The data of lightweight tone is collected for each vessel/age from various sources and their average is taken to calculate scrap value. For further application for application of SQ, the exact LDT can be used to calculate the indicator.

this model. Considering the basics of DCF calculation, SQ is calculated for each vessel and age group of dry bulk and tanker. The formulation of SQ indicator is provided below:

$$\Phi_Q = \frac{SH_{n,t}}{NPV_{n,t}}, \qquad (3.1)$$

$$NPV_{n,t} = \sum_{t=1}^{T} \frac{(R_{n,t} - \text{OPEX}_{n,t})}{(1+i)^t} + \frac{SCRP_{t+i}}{(1+i)^t} \qquad (3.2)$$

$$R = TC_n * 350 \qquad (3.3)$$

$$\text{OPEX}_{n,t} = OPEX_{daily} * 365 \qquad (3.4)$$

$$SCRP_{t+i} = SCRP_{ton} * LDT_n \qquad (3.5)$$

Where, Φ_Q is a ratio of the nominal price of the ship to the market price,

$SH_{n,t}$ is a second-hand price of a n ship at age t,

$NPV_{n,t}$ is a nominal price of a n ship at age t,

R is the estimated revenue for n^{th} ship at time t,

$\text{OPEX}_{n,t}$ is operating expense of a n ship at time t,

$SCRP_{t+i}$ is a scrap price for n ship at the end of economic life, t+i

TC_n is a one-year time charter rate for n ship,

$OPEX_{daily}$ is a daily operating expense,

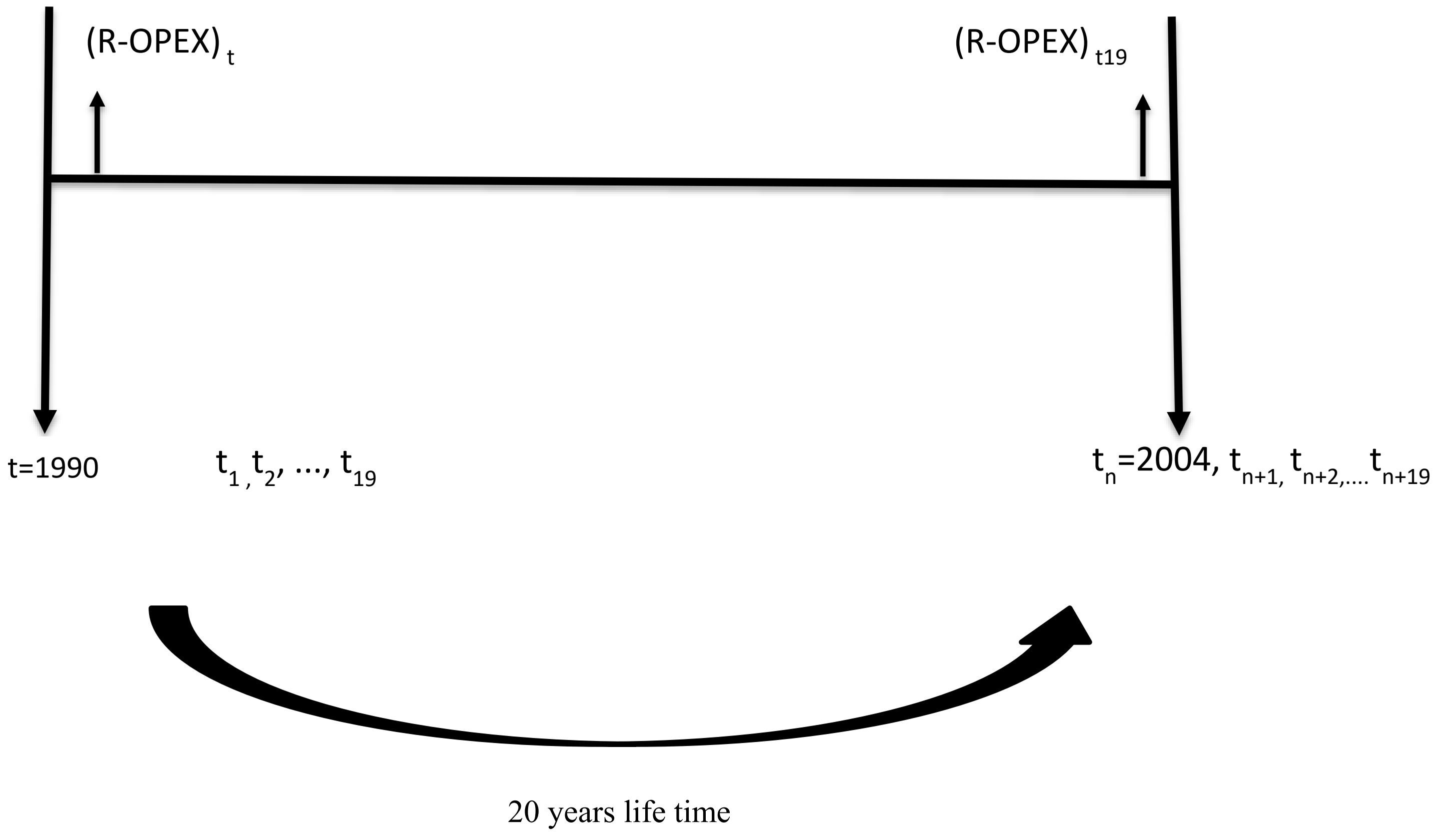
$SCRP_{ton}$ is scrap prices per ton,

LDT_n is a lightweight ton for n ship.

As illustrated below, SQ was calculated for each vessel type of dry bulk and tanker carriers. The sample group from 1990 to 2017 grouped by 20 years life span of a ship, and each cash flow has been calculated based on 20 years of lifetime. The first set of cash of analysis has been conducted from 1990 to 2009, from *t* to *t+19*, and the following set of analyses was continued to calculate following 20 years of cash flow analysis, from *t+1* to *t+20*. This has been repeated until the end of the sample period, from 2017 to 2036, from *t+27* to *t+46*. For each vessel type and age group, these calculations have been repeated.

Numerically, 280 yearly SQ indicators for tanker carriers and 280 yearly SQ indicators for dry bulk carriers; 3,244 monthly SQ indicators for dry bulk carriers and 3,327 monthly SQ indicators for tanker carriers have been created. In total, 7,131 individual indicators created a monthly and yearly basis to evaluate the valuation disparity between the market price and the nominal value of a ship following the fundamental approach of the Tobin Q investment model. The calculation of the SQ indicator is illustrated in Figure 3.1.

SQ indicator has been calculated in two forms: yearly and monthly. Yearly SQ indicator provided a critical output to elaborate main argument and showed the gap between short-run pricing (market value) and the long-term valuation, while monthly SQ demonstrated definitive evidence about the valuation gap between nominal price and the market price of the SH ships.



$$NPV_{n,t} = \sum_{t=1}^{T} \frac{(R_{n,t} - \mathrm{OPEX}_{n,t})}{(1+i)^t} + \frac{SCRP_{t+i}}{(1+i)^t} \quad (3.2)$$

Figure 3.1: Shipping Q Calculation Illustration

The SQ indicator as a market guiding indicator can provide some certain benefits to the market participants in terms of anticipating the future direction of the market. The calculated value of a ship in the SQ indicator is an estimated natural price of a ship, which is found by estimating future cash flows assuming the mean-reverting ship market. Mean reversion assumes that the market price tends to move to the average price over time (Hillebrand, 2003). The mean-variance strategy is also found statistically significant on various sample data, such as asset portfolio (Caporin et al., 2012). Following the mean reversion assumption, this method calculates the long term value of a ship. Therefore, the SQ indicator guides the future shift of the shipping market.

3.4 Shipping Q Optimization

Investment timing and investment return performance have been researched by various methods, such as price-earnings ratio real option analysis (Alizadeh et al., 2007), and option pricing method. Necessarily, these methods interpret market fluctuations and price movements to pick the best time to invest and gain maximum return. Similarly, the SQ indicator was tested for the different upper and lower bands to find out the best combination to invest and gain maximum return for the given data set. In the optimization of SQ, the fundamental approaches of value maximization theory have been used.

In the fundamental optimization problem, the equation is formed as in equation (3.6):

$$\text{minimize } f_o(x)$$

$$\text{subject to } f_i(x) \leq b_i, \quad i = 1, \dots, m \qquad (3.6)$$

In the given equation 3.6, the vector $x = (x_1, \dots, x_n)$ is the optimization variables of the problem, the function $f_o\colon R^n \to R$ is the objective function, the functions $f_i : R^n \to R$,

$i = 1,\ldots,m$, are the constraint functions, the constants $b_1, \ldots, b_m$ are the limits for the constraints. A vector x^* is an optimal solution to the problem (Boyd et al., 2004). In convex optimization problems, the objective and constraint functions are convex. It is considered that convex optimization to be a generalization of linear programming. The optimization problem (3.6) illustrates the problem of picking the best possible choice of a vector R^n in a set of alternatives. The variable x stands for the chosen alternative, the constraints $f_i(x) \leq b_i$ stands for the specific requirements that limit the possible choices, and the objective value $f_o(x)$ is the cost of choosing the variable x. A solution of the optimization problem (3.6) corresponds to the choice that has a minimum cost or maximum return, among all choices that meet the requirements or limitations.

The main principle of expected value maximization states that a rational investor, when faced with several investment alternatives, acts to select an investment that maximizes the expected value of wealth (Boyd et al., 2004; Morgenstern et al., 1953). As given in equation 3.7, for each investment *I* in a set of possible investment alternatives (buy and sell options) *B/S,* assume X(I) be the random variable giving the ending value of the investment for the time period in the data set. A rational investor with the function U faces the optimization problem of deciding on the investment options $I_{opt} \in B/S$ for which:

$$E\left(U\left(X\left(I_{opt}\right)\right)\right) = \max_{I \in B/S} E\left(U\left(X(I)\right)\right) \quad , (3.7)$$

X(I) is an amount produced by the end of the given sample period for the SH ship. A rational investor tends to maximize it through buy and sell options; in other words, the function is to be optimized subject to total return gained at the end of the sample period/ at the end of ship life.

Monitoring sharp price decreases are relatively more straightforward than the usual market up and downs. To take advantage of the usual market up and downs, there should be a tool to generate a long-term market signal to produce an early warning system for possible asset bubbles. Therefore, SQ is optimized to identify an upper and lower band of buy and sell signals for each type of vessel. According to Tobin (1969), buy and sell signals need to be set below 1.00, and above 1.00, which means if the market value of an asset is over its book value, then there is overvaluation, and the investment needs to be delayed. However, merely running asset management according to the strategy of "*buy if it is below 1.00 and sell if it is above 1.00 level*" might not reveal the best outcome. Therefore, the optimization of monthly SQ can be able to explain the best upper and lower level to decide where an investor obtain maximum investment return. To address this issue, the optimization of buy and sell signals for each vessel type tested within the upper and lower bands were identified by applying the value maximization approach (Boyd et al., 2004).

The optimization is organized and applied for each vessel type separately from 1995 to 2015. It is assumed that the same initial capital is applied, 100 million USD[10], and seeking to buy a 5- year-old vessel. Where the first buy signal comes, after a three-month waiting period, assumed to be the time gap between the decision and the ship purchase, cash outflows are shown, and operational income is estimated as a cash inflow throughout the period the ship operates until the first sell signal. Operational income is calculated as revenues (time charter rate multiplied by 350) minus operating expenses (daily operating expenses multiplied by 365). After the first sell signal, again three-month time-lapse is counted, and the ship is sold at the corresponding SH price. Sell income is added to the

[10] The amount is set as a symbolic number, which stands for a fixed amount applied to all scenarios.

cash flow. The buy and sell operations continued from 1995 to 2015. At the end of 2015, if assets are still not sold, they are accepted as sold at the corresponding SH price in the market.

The optimization algorithm is illustrated in Figure 3.2 and explained below:

Step 1: Identify the upper and lower band to test by the trial method

Step 2: Calculate expected cash flows and operating expenses from 1995 to 2015

Step 3: Wait until the first buy signal

Step 4: After the first buy signal, buy ships after three months period, considering the decision-making time gap (Cash outflows)

Step 5: Proceed with net income (total revenues minus operating expenses) until the first sell signal (Cash inflows)

Step 6: After first sell signal, sell the ship after three months period at the corresponding SH ship price (Cash inflows)

The buy and sell operations continue until the end of a sample period

Step 7: At the end of the sample period 2015, if ships are still operating, they are sold at the corresponding SH ship price (Cash inflows).

It is expected to reveal different investment performance intervals for each vessel at different investment return maximization levels. According to the principles of the value maximization theory, the highest investment return level is to be determined with the upper and lower bands of the SQ indicator.

As obtained by the calculation of SQ indicators for the tanker and dry bulk markets, the average lowest and highest SQ levels were moving between 0.5 and 1.5. To provide a more detailed picture of SQ indicators, the bands (0.50: 1.50) were considered to identify the upper and lower levels to optimise tanker and dry bulk carriers' SQ indicators by considering most indicative levels of SQ indicators. More specifically, to determine the lowest average level for the buy signal of the dry bulk carrier, the range from 0.10 to 1.00 levels were tested with different combinations of SQ indicators, after series of trials, it was found that the most profitable average level to buy a second-hand dry bulk ship ranges between 0.50 and 1.00. More detailed discussions have been reported in Chapter 5. To determine sell level of second-hand dry bulkers, the same method has been applied to the optimisation scenarios by testing various intervals from 1.00 to 2.00 levels, and the results showed that levels from 1.00 to 1.50 could optimise the sell signal. Consequently, the intervals of dry bulk and tanker carriers have been identified through test and trial process. Series of different combinations were tested, and the most profitable scenarios are reported in the thesis.

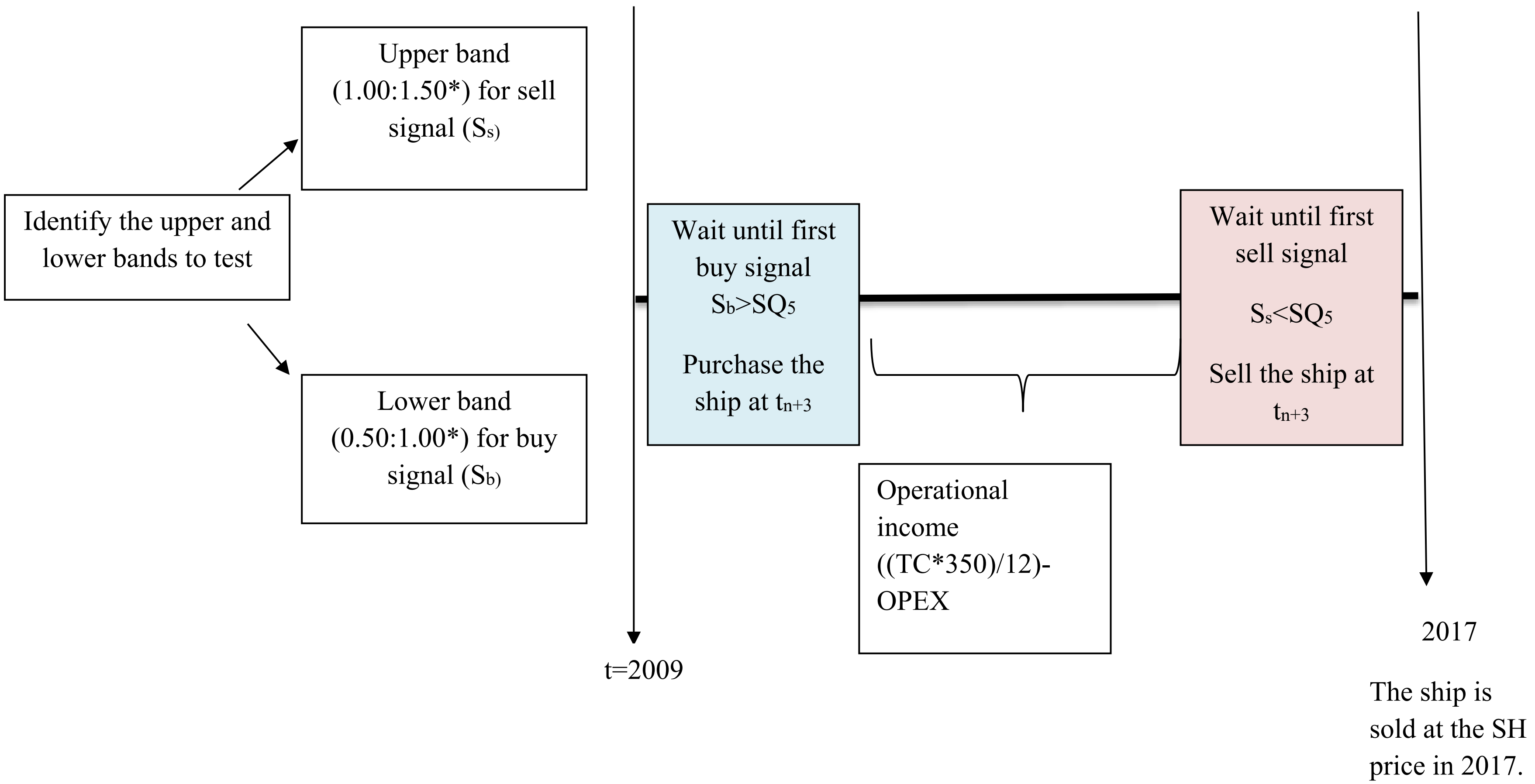


Figure 3.2: Shipping Q Optimization Illustration

*Lower (0.50:1.00) and upper (1.00:1.50) levels were determined by the tanker and dry bulk SQ indicators' average lowest and highest level.

3.5 Sample Data and Sources

As previously discussed, industry-level data can bring several advantages such as a large sample data set, reliable results and more targeted users, which has been widely used in previous studies (Alizadeh et al. (2007) Merikas et al. (2008); N. Papapostolou et al. (2017)). As a result, in this research, the sample data is collected based on industry-level data.

The sample period spans from 1976 to 2017. Sample data is collected from Time charter rate, and SH prices are obtained from Clarkson Shipping Intelligence, scrap prices, and operational expenses data are collected from Drewry. The proposed model to be set out for each vessel type for dry bulk and tanker ships. For tankers, vessels are grouped as and Handysize[11], Suezmax, Panamax, Aframax, and ULCC/VLCC; for dry bulk, they are grouped as Handysize, Handymax, Panamax, and Capesize.

3.6 Variables

The calculation of the SQ indicator involves some variables: time charter rate, operating expenses, scrap prices, discount rate, and SH ship prices. Following the SQ calculation, the estimated long-term value of a ship is measured by the NPV of a vessel. The monthly and yearly revenues are calculated as the 10-year average of the time charter rate multiplied by 350. It is assumed that the ship is operated 350 days in a year (Stopford, 2009). One-year-time-charter rate is used in this data set to minimize short term rate fluctuations and consider long term effects on revenue (Daniel Glen et al., 1981; Hawdon, 1978). Time charter rates thus reflect expectations of future profitability in the spot

[11] The features of vessel are provided in Appendix 1.

freight market, which in turn depends positively on expected freight rates and negatively on expected bunker prices (M. G. Kavussanos, 1996).

Shipping expenses are generally classified as operating costs (OPEX), Periodic maintenance costs, voyage costs (VOYEX), capital costs (CAPEX), cargo-handling costs (Stopford, 2009). OPEX are the ongoing expenses connected with the day-to-day running of the vessel together with an allowance for day-to-day repairs and maintenance (but not major dry dockings, which are dealt with separately). The 10-year average of OPEX is used in this data set to deduct from revenue, since it corresponds to the fixed expenses, such as crew expenses, store, lubricants, repair and maintenance, insurance and administration costs. VOYEX, which are fuel, port charges, and canal dues, and capital costs (CAPEX) depends on the price in the market and financial situation of shipowners, respectively, therefore they are highly volatile expenses and hard to predict them for long term analysis. In particular, CAPEX is directly linked to the investor's own financial situation; either the investor uses their funding option or using external funding options. VOYEX is also determined by the volatile market price. Therefore it is not feasible to predict it for this model.

Scrap prices are calculated for each vessel segment of tanker and bulker by multiplying the lightweight of the ship by the scrap price. As scrap valuation described by Stopford (2009, p. 265), first, the light displacement tonnage (LDT) of each ship has been established to obtain the physical weight of the vessel. Second, the current scrap price per LDT for each ship has been collected. Finally, the scrap value is calculated by multiplying the lightweight of the ship by the scrap price, and the 10-year average of scrap prices is used.

The figures are discounted by monthly long-term government bond yields of 10-year. Although the London Interbank Offered Rate (LIBOR) is accepted as the most applied discount factor, after the GFC, 2008, its reliability decreased, and government bond yields ratios are mostly preferred (Stroebel et al., 2009).SH ship prices (5, 10- and 15-year-old) are used as a replacement cost in the SQ model. The evaluation of the replacement cost is defined as the SH price of a corresponding ship. The shipping industry is a rare industry which is having two active trading markets, SH and newbuilding, attracts investors, and thus each market is treated as a substitute market under some specific conditions (Tsolakis et al., 2003). The SH market is a substitute market of a new building when investor tends to enter to the market not willing to expose to delivery lag.

The use of SH ship price instead of a new building ship price as a basis for replacement cost assumes that the investor evaluates options to generate revenues immediately at the specific market conditions. A new build ship requires 2-3 years of construction and will be delivered in different market conditions; thus, it cannot be considered a replacement investment but an investment for expansion. Therefore, replacement cost is defined by the SH ship price.

3.7 Summary

Chapter 3 outlines the adaptation of the Tobin Q model to the shipping industry, indicator calculation, optimization, sample data, and variables. Section 3.2 presented the adaptation of the Tobin Q model to the shipping industry, and Section 3.3 elaborated the method used to calculate the SQ indicator. The optimization method is presented in Section 3.4. Section 3.5 introduced sample data to be used in the model, the sources and limitations of this research in terms of sample data, which is limited to dry bulk and tanker ship investments from 1976 to 2017. Lastly, Section 3.6 provided the source and definition of each variable used in the indicator calculation.

Chapter 4 Shipping Q Results and Analysis

4.1 Introduction

In this chapter, SQ indicator results are presented for dry bulk and tanker ships, and the implication of the SQ indicator is discussed. Section 4.2 introduces the SQ indicator calculations. Yearly and monthly results of the SQ indicator, together with descriptive statistics, are presented in Section 4.3 and Section 4.4, respectively. The results are used to demonstrate ship valuation mismatch and the bubble pricing of shipping assets. Chapter 4 also provides the discrepancy between market prices and the long-term nominal value of a shipping asset, reflecting any mispricing. This, in turn, sheds light on investment timing and market entry-exit decisions. Along with the SQ indicator analysis, Section 4.5 provides a sensitivity analysis of the economic life of a ship and the TC rate averages. Finally, Section 4.6 summarizes this chapter.

4.2 Shipping Q indicator

The SQ indicator was calculated based on the principles of Tobin Q theory; however, the interpretation of the SQ indicator was made following the contemporary approach developed for the Q model (Mihaljevic, 2013). When adapting the Q model in asset valuation and creating buy and sell warning systems for the shipping industry, it is more realistic to interpret the adapted model's signals as if Q is greater than 1, sell, and if Q is lower than 1, buy. The interpretation of SQ indicator for the dry bulker and tanker SH markets has been made following the updated approach, which is, if SQ is over level

1.00, then ship is overvalued, and signal is interpreted as a "sell"; if SQ is below level 1.00, then ship is undervalued, and signal is interpreted as a "buy".

The SQ indicator is calculated in two forms: yearly and monthly[12]. Yearly and monthly SQ indices demonstrate the difference between market price and long-term nominal value of SH prices. For example, from 2003 to 2008, the difference between nominal price and market price of SH prices remarkably increased, which indicates asset bubbles in the market during this period, and therefore, overvaluation occurred. The period from 2003 to 2008 was a remarkable era in the history of the shipping industry and the world economy. Ship prices in both SH and newbuilding markets have immensely increased due to continuous world economic growth and higher demand for shipping services. Rocketing ship prices and freight rates had significantly dropped during and after the 2008 GFC period. In particular, after the 2008 GFC, the spot market price of SH Capesize bulk carrier had dramatically dropped to $40 million from $140 million in just six months from June to December 2008[13]. Figure 4.1 illustrates the price-value disparity between market prices and the long-term nominal value of a shipping asset. From 2006 to 2008, the price-value disparity reached its peak level.

The extreme price drops in the SH ship market are followed by decreasing funding opportunities supplied by the banks and financial institutions, and consequently, shipping company bankruptcies (Lozinskaia et al., 2017). It was difficult to predict the 2008 GFC and foresee its destructive impact on financial markets and the shipping industry. However, it is feasible to dissolve shipping market dynamics with forecasting tools, like SQ or RSI, to understand the price-value disparity and, therefore, risks in the market. A

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[12] SQ indicator yearly and monthly results are available to download online https://1drv.ms/b/s!Ak84XCAHzbD6jkfsLzeQkS_KA4Ee

[13] Data is downloaded from Clarkson at 09 November 2017.

forecasting tool like SQ helps to manage the risk and provide an option to take a position in a dynamic market beforehand.

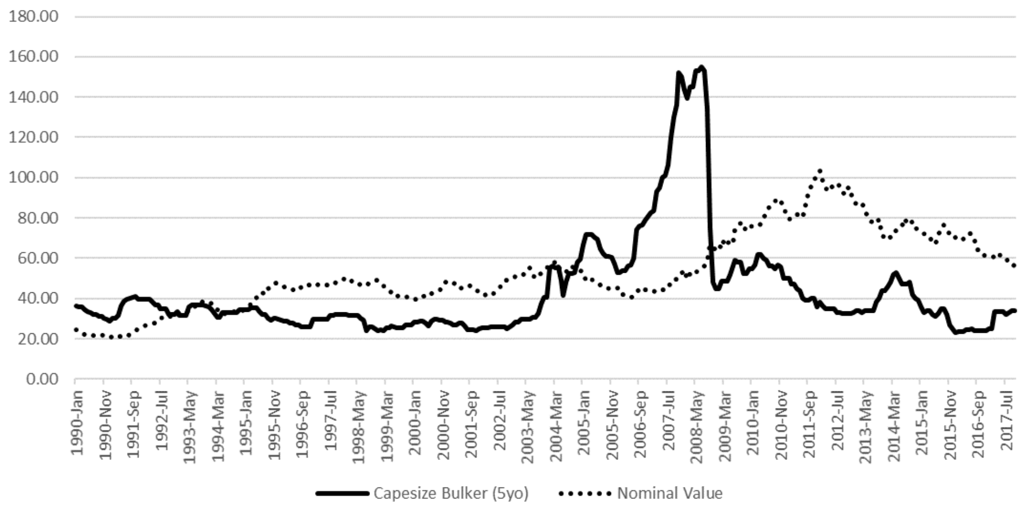


Figure 4.1. Comparison of the Market Price and the Nominal Value of a SH Capesize Bulker

Source: Author (nominal value), Clarkson (Capesize SH prices)

As discussed in Chapters 2 and 3, the SQ indicator shows over- and undervaluation of a ship acting as a signal for sale or purchase based on market price and long-term nominal value of the SH ship, which sheds light on the ship investment timing. The SQ indicator is applied indiscriminately to both the dry bulk and tanker markets without catering for the different dynamics of the two shipping sectors. The different demand dynamics of the two sectors possibly affect both freight volatility and SH ship values. The application of the indicator inherently takes into consideration the different structure dynamics based on the historical data of each section. In the following sections, yearly and monthly results of the SQ indicator for dry bulk and tanker ships are presented. Yearly SQ results provided the solid ground to deepen the research within the price-value disparity between market price and long-term nominal value of SH ships. Notably, the snowballing gap between market price and long-term nominal value of SH ships throughout 2003 and

2008 encourages further monitoring of the monthly SQ changes. This presents a more in-depth view of price changes in the SH ship market and also leads to run optimization subject to total investment return for dry bulk and tanker markets. Therefore, both yearly and monthly SQ results are calculated to contribute to both short- and long-term investment decisions.

4.3 Yearly Results of the SQ indicator

Before presenting yearly results of the SQ indicator, descriptive statistics and correlation analysis have been applied to investigate the link between SQ indicator, TC rate, and SH ship prices of dry bulk carriers and tankers. The TC rate and SH ship prices are reliable market indicators for future shipping asset management (Haralambides et al., 2005). Therefore, the SQ indicator is compared with these two variables by using cross-correlation analysis to reveal the time lag between the variables. Furthermore, the cross-correlation analysis enables investigating how the changes in the TC rates and SH prices respond to the buy and sell signals of the SQ indicator.

4.3.1 Descriptive Statistics

Table 4.1 reports descriptive statistics of yearly TC rates, SH prices, and SQ for dry bulk carriers and tankers. First, the results of TC rates indicated that the mean for larger vessels is higher than smaller ones. Unconditional volatility (standard deviations) showed a similar trend to the mean levels across all ship sizes. When the volatility and ship size increases are considered, it is appropriate to state that the TC rates for larger vessels fluctuate more than smaller ones (M. Kavussanos et al., 2002). The TC rate was positively skewed, and it tends to increase as the vessel tonnage increases. Moreover, the kurtosis of the TC rate was significantly high; for example, Handysize TC is 8.48, which indicated a sharper peak in the sample. Having higher kurtosis results for TC rate was expected due to the extreme price increases in TC rates from 2004 to 2008.

Secondly, yearly results of SH prices also followed a similar mean trend as that the TC rate showed, where the mean of SH prices was higher for the larger vessels than smaller ones. The standard deviation of SH prices indicated that larger vessel prices were more volatile than smaller ones. Furthermore, both mean and standard deviation of SH ship prices showed that younger ships had a higher mean than older ships, and younger ships were more volatile than older ships for dry bulk and tanker. SH prices were positively skewed for both dry bulk carriers and tanker vessels. The kurtosis of SH prices was considerably high, which ranges between 3.49 and 8.52 for the dry bulk carrier; and ranges between 2.21 and 4.68 for the tanker, which indicates that the sample data has a non-normal distribution.

Thirdly, yearly results of the mean SQ for dry bulk and tanker were less volatile, mostly showing a steady trend, ranging between 0.004 and 0.109 for the dry bulk vessels and 0.004 and 0.034 for the tankers. As shown in Table 4.1, the mean SQ is relatively higher for the smaller ships than larger ships. The standard deviation of the SQ also showed a stable trend. It recorded the highest level on Handysize 15-year-old, the lowest level of standard deviation monitored in Capesize 10-year-old. The rest of the vessels tend to move around a 0.7% level. Also, the mean SQ of the tanker was lower than 0.7% level, except VLCC 15-year-old, which was 3.4%, and the standard deviation did not exceed the level of 0.06%. The SQ indicator was positively and highly skewed for both dry bulk carrier and tanker vessels, and the kurtosis was significantly high. Those indicate the asymmetric distribution in the sample data. This was expected due to the recent extreme price shocks in TC rate and SH prices since the SQ indicator consists of TC rate and SH prices.

The descriptive analysis can provide preliminary evidence of high volatility in the SH prices and the TC rate, which supports the main argument of this research, to reveal the price disparities between the market price and long-term nominal value of SH ships due to volatility in the markets. The descriptive statistics of the SQ indicator is less volatile. However, it is non-normal distributed.

Turning to correlation analysis, Tables 4.2 showed the correlation coefficients among TC rates, SH prices, and the SQ indicator for dry bulk carriers. Overall, there was a high correlation coefficient in the series. As per the literature (Dai et al., 2015; M. G. Kavussanos, 1997; Tsolakis et al., 2003), there was a positive correlation between the SQ indicator and tow variables, TC rate, and SH prices, both of which were also positively correlated. The SQ stands for the ratio of SH prices to the nominal value of a ship. As the SH prices exceeded the nominal prices, SQ went over level 1.00, in which case, both variables increased. Therefore, the positive correlation was observed between the SQ indicator and SH prices. The same correlation mechanism was followed by TC rates and SQ indicators. The correlation analysis proves that the link between SQ, SH, and TC was strong. Furthermore, the cross-correlation analysis is conducted to reveal leading time-lag from SQ to TC rates and SH prices. The outputs of the cross-correlation were discussed in the SQ analysis section for both dry bulk and tanker carriers.

More specifically, dry bulk correlation matrices indicate that as the ship size increase, the correlation coefficient of SQ with SH and TC increases, except for Capesize 5 and 10-year-old. Capesize $SQ_{5,10}$ exceeded level 1.00 from 1990 to 1996, which was due to the level of nominal ship value being below market price during the given time frame. The correlations of Capesize $SQ_{5,10}$ with SH and TC are weakened during this term, and the weakened relationships were also monitored during the peak level from 2006-2008. This shows that although the nominal value of the Capesize kept decreasing during the given time frame, SH prices and TC rates keep increasing. The main reason for the low correlation between SQ and TC rate and SH might be due to the small sample. In the yearly data sample, 110 observations were tested in the correlation analysis, while in the monthly data set, more than 1000 observations were tested. The short-term disparities and volatilities were analyzed using a large sample.

Correlation analysis is also conducted for tankers and presented in Table 4.3. Overall, correlations between SH prices and TC rate are considerably high, but in some cases, the correlation between SQ and SH prices and TC rate are low. For example, the correlation between SQ_5 and TC rate and SH prices are notably lower than older vessels. The highest correlation between SQ and the two variables was observed for 15-year-old tanker vessels. 10-year-old vessel results are quite complicated, while the highest correlation between SQ and two variables are observed in Aframax, the lowest correlation was obtained for Suezmax and VLCC. Results of 10-year-old product tankers indicated a moderate correlation. The weak correlation between SQ and two variables can be explained by a couple of scenarios; first, the inelastic demand for the product carried by the tankers. Regardless of the price changes in the market or SQ indicator level, the demand for tanker services stays at a consistent level (Lun et al., 2012). Second, the weak correlation may be due to the impact of the ownership structure of the tanker market on the pricing mechanism. As D Glen et al. (2002); Veenstra et al. (2006) stated, the ownership structure had changed dramatically from the1950s till now. The ownership structure was characterized as a 50/50 split between the spot market and oil companies in the 1950s. However, oil companies majorly chartered the spot market tankers by the TC contracts and dominated the tanker market (Veenstra et al., 2006). This might have violated perfect competition conditions, where the price was not freely set by the market. After the 1950s, the tanker capacity held by major oil companies gradually decreased.

Table 4.1 Descriptive Statistics of Output and Input Variables for Yearly SQ (1990-2017)

Bulker/Handysize$_5$		Mean	Standard deviations	Skewness	Kurtosis	Tanker/ Product$_5$		Mean	Standard deviations	Skewness	Kurtosis
SH_5	β_5	14.321	8.25	1.532	5.841	SH_5	β_5	21.214	9.742	0.986	3.986
SQ	Φ_{sq}	0.012	0.007	1.22	4.031	SQ	Φ_{sq}	0.007	0.003	0.692	2.921
TC	∞	8,736.48	5,625.28	2.287	8.475	TC	∞	13,141.91	5,455.06	0.832	3.626
Bulker/Handysize$_{10}$						Tanker/ Product$_{10}$					
SH_{10}	β_{10}	14.084	7.713	1.647	5.213	SH_{10}	β_{10}	17.434	7.240	1.816	5.356
SQ	Φ_{sq}	0.013	0.011	1.936	6.263	SQ	Φ_{sq}	0.006	0.002	0.947	3.302
TC	∞	8,736.48	5,625.28	2.287	8.475	TC	∞	13,141.91	5,455.06	0.832	3.626
Bulker/Handysize$_{15}$						Tanker/ Product$_{15}$					
SH_{15}	β_{15}	11.588	7.262	1.115	3.494	SH_{15}	β_{15}	14.72	6.478	1.150	2.744
SQ	Φ_{sq}	0.016	0.018	1.664	4.965	SQ	Φ_{sq}	0.006	0.002	0.923	2.716
TC	∞	8,736.48	5,625.28	2.287	8.475	TC	∞	13,141.91	5,455.06	0.832	3.626
Bulker/Handymax$_5$						Tanker/ Aframax$_5$					
SH_5	β_5	21.598	11.554	2.003	7.244	SH_5	β_5	30.751	16.232	0.64	3.104
SQ	Φ_{sq}	0.012	0.007	1.472	5.764	SQ	Φ_{sq}	0.008	0.003	0.939	4.6
TC	∞	13,126.89	9,991.15	2.244	7.48	TC	∞	16.332.25	8,476.02	0.684	2.935
Bulker/Handymax$_{10}$						Tanker/ Aframax$_{10}$					

SH_{10}	β_{10}	17.874	10.234	1.968	6.448
SQ	Φ_{sq}	0.012	0.007	1.521	5.22
TC	∞	13,126.89	9,991.15	2.244	7.48
Bulker/Handymax$_{15}$					
SH_{15}	β_{15}	14.789	10.061	1.372	4.146
SQ	Φ_{sq}	0.109	0.012	1.550	4.573
TC	∞	13,126.89	9,991.15	2.244	7.48
Bulker/Panamax$_{5}$					
SH_{5}	β_{5}	21.370	13.710	2.028	7.689
SQ	Φ_{sq}	0.012	0.007	1.384	4.945
TC	∞	13,171.90	11,165.89	2.528	9.381
Bulker/Panamax$_{10}$					
SH_{10}	β_{10}	20.574	13.101	1.903	6.025
SQ	Φ_{sq}	0.010	0.008	1.878	6.213
TC	∞	13,171.90	11,165.89	2.528	9.381
Bulker/Panamax$_{15}$					
SH_{15}	β_{15}	17.093	12.303	1.374	4.035
SQ	Φ_{sq}	0.012	0.012	1.547	4.655
TC	∞	13,171.90	11,165.89	2.528	9.381

SH_{10}	β_{10}	29.418	12.818	1.291	3.244
SQ	Φ_{sq}	0.006	0.003	0.547	2.282
TC	∞	16.332.25	8,476.02	0.684	2.935
Tanker/ Aframax$_{15}$					
SH_{15}	β_{15}	16.806	7.003	1.34	4.689
SQ	Φ_{sq}	0.005	0.002	0.356	1.921
TC	∞	16.332.25	8,476.02	0.684	2.935
Tanker/ Suezmax$_{5}$					
SH_{5}	β_{5}	42.434	20.912	0.457	3.271
SQ	Φ_{sq}	0.008	0.004	1.080	4.159
TC	∞	21,225.80	11,604.46	0.740	2.577
Tanker/ Suezmax$_{10}$					
SH_{10}	β_{10}	35.852	15.535	1.555	4.348
SQ	Φ_{sq}	0.007	0.004	0.822	3.577
TC	∞	21,225.80	11,604.46	0.740	2.577
Tanker/ Suezmax$_{15}$					
SH_{15}	β_{15}	25.68	9.912	0.665	2.402
SQ	Φ_{sq}	0.004	0.002	1.106	4.15
TC	∞	21,225.80	11,604.46	0.740	2.577

Bulker/Capesize$_5$						Tanker/ VLCC$_5$					
SH_5	β_5	36.407	23.511	2.223	8.522	SH_5	β_5	56.225	33.134	0.448	3.023
SQ	Φ_{sq}	0.009	0.006	0.601	2.303	SQ	Φ_{sq}	0.009	0.006	1.773	5.971
TC	∞	21,493.21	23,505.60	2.728	10.207	TC	∞	26,415.80	17,009.25	0.806	3.030
Bulker/Capesize$_{10}$						Tanker/ VLCC$_{10}$					
SH_{10}	β_{10}	30.756	20.104	1.9	6.044	SH_{10}	β_{10}	51.503	22.201	1.660	4.751
SQ	Φ_{sq}	0.006	0.004	1.052	3.727	SQ	Φ_{sq}	0.007	0.004	1.504	5.376
TC	∞	21,493.21	23,505.60	2.728	10.207	TC	∞	26,415.80	17,009.25	0.806	3.030
Bulker/Capesize$_{15}$						Tanker/ VLCC$_{15}$					
SH_{15}	β_{15}	25.287	19.165	1.589	4.54	SH_{15}	β_{15}	29.221	10.002	0.501	2.213
SQ	Φ_{sq}	0.004	0.006	1.604	4.767	SQ	Φ_{sq}	0.034	0.001	0.640	2.177
TC	∞	21,493.21	23,505.60	2.728	10.207	TC	∞	26,415.80	17,009.25	0.806	3.030

Source: Author (SQ indicator), Clarkson (TC rate & SH prices)

Table 4.2 Correlation Matrix of Dry Bulker Carrier TC Rate, SH Prices, and SQ (1990-2017)

Handysize$_5$		β_5	Φ_{sq}	∞	Handysize$_{10}$	β_{10}	Φ_{sq}	∞	Handysize$_{15}$	β_{15}	Φ_{sq}	∞
SH_5	β_5	1.0000			β_{10}	1.0000			β_{15}	1.0000		
SQ	Φ_{sq}	0.6700 (0.0001)	1.0000		Φ_{sq}	0.7897 (0.0000)	1.0000		Φ_{sq}	0.8162 (0.0001)	1.0000	
TC	∞	0.9564 (0.0000)	0.7448 (0.0000)	1.0000	∞	0.9590 (0.0000)	0.8561 (0.0000)	1.0000	∞	0.9672 (0.0000)	0.8597 (0.0000)	1.0000
Handymax$_5$		β_5	Φ_{sq}	∞	Handymax$_{10}$	β_{10}	Φ_{sq}	∞	Handymax$_{15}$	β_{15}	Φ_{sq}	∞
SH_5	β_5	1.0000			β_{10}	1.0000			β_{15}	1.0000		
SQ	Φ_{sq}	0.6819 (0.0001)	1.0000		Φ_{sq}	0.7273 (0.0000)	1.0000		Φ_{sq}	0.8075 (0.0001)	1.0000	
TC	∞	0.9522 (0.0000)	0.7263 (0.0000)	1.0000	∞	0.9515 (0.0000)	0.7770 (0.0000)	1.0000	∞	0.9523 (0.0000)	0.8852 (0.0000)	1.0000
Panamax$_5$		β_5	Φ_{sq}	∞	Panamax$_{10}$	β_{10}	Φ_{sq}	∞	Panamax$_{15}$	β_{15}	Φ_{sq}	∞
SH_5	β_5	1.0000			β_{10}	1.0000			β_{15}	1.0000		
SQ	Φ_{sq}	0.7397	1.0000		Φ_{sq}	0.8171	1.0000		Φ_{sq}	0.8385	1.0000	

		(0.0000)				(0.0000)				(0.0000)		
TC	∞	0.9672	0.7734	1.0000	∞	0.9639	0.8469	1.0000	∞	0.9674	0.8671	1.0000
		(0.0000)	(0.0000)			(0.0000)	(0.0000)			(0.0000)	(0.0000)	
Capesize$_5$		β_5	Φ_{sq}	∞	Capesize$_{10}$	β_{10}	Φ_{sq}	∞	Capesize$_{15}$	β_{15}	Φ_{sq}	∞
SH$_5$	β_5	1.0000			β_{10}	1.0000			β_{15}	1.0000		
SQ	Φ_{sq}	0.3650	1.000		Φ_{sq}	0.6549	1.0000		Φ_{sq}	0.8550	1.0000	
		(0.0562)				(0.0004)				(0.0000)		
TC	∞	0.9638	0.3938	1.000	∞	0.9661	0.7733	1.0000	∞	0.9794	0.9032	1.0000
		(0.0000)	(0.0381)			(0.0000)	(0.0000)			(0.0000)	(0.000)	

Source: Author (SQ indicator), Clarkson (TC rate & SH prices)

P-values are given in the parenthesis

Table 4.3 Correlation Matrix of Tanker TC Rate, SH Prices, and SQ (1990-2017)

Product$_5$		β_5	Φ_{sq}	∞	Product$_{10}$	β_{10}	Φ_{sq}	∞	Product$_{15}$	β_{15}	Φ_{sq}	∞
SH$_5$	β_5	1.0000			β_{10}	1.0000			β_{15}	1.0000		
SQ	Φ_{sq}	0.1844 (0.3475)	1.0000		Φ_{sq}	0.4930 (0.0077)	1.0000		Φ_{sq}	0.9177 (0.0000)	1.0000	
TC	∞	0.9217 (0.0000)	0.1125 (0.5688)	1.0000	∞	0.8943 (0.0000)	0.3734 (0.0503)	1.0000	∞	0.9214 (0.0000)	0.9419 (0.0000)	1.0000
Aframax$_5$		β_5	Φ_{sq}	∞	Aframax$_{10}$	β_{10}	Φ_{sq}	∞	Aframax$_{15}$	β_{15}	Φ_{sq}	∞
SH$_5$	β_5	1.0000			β_{10}	1.0000			β_{15}	1.0000		
SQ	Φ_{sq}	0.2120 (0.2787)	1.0000		Φ_{sq}	0.8113 (0.0000)	1.0000		Φ_{sq}	0.8511 (0.0000)	1.0000	
TC	∞	0.9224 (0.0000)	0.2726 (0.1605)	1.0000	∞	0.8932 (0.0000)	0.8340 (0.0000)	1.0000	∞	0.8373 (0.0000)	0.9249 (0.0000)	1.0000
Suezmax$_5$		β_5	Φ_{sq}	∞	Suezmax$_{10}$	β_{10}	Φ_{sq}	∞	Suezmax$_{15}$	β_{15}	Φ_{sq}	∞
SH$_5$	β_5	1.0000			β_{10}	1.0000			β_{15}	1.0000		
SQ	Φ_{sq}	-0.2200	1.0000		Φ_{sq}	0.0382	1.0000		Φ_{sq}	0.9076	1.0000	

		(0.2607)				(0.8469)				(0.0000)		
TC	∞	0.8968 (0.0000)	-0.2227 (0.2546)	1.0000	∞	0.8306 (0.0000)	-0.1051 (0.5947)	1.0000	∞	0.8379 (0.0003)	0.9534 (0.0000)	1.0000
$VLCC_5$		β_5	Φ_{sq}	∞	$VLCC_{10}$	β_{10}	Φ_{sq}	∞	$VLCC_{15}$	β_{15}	Φ_{sq}	∞
SH_5	β_5	1.0000			β_{10}	1.0000			β_{15}	1.0000		
SQ	Φ_{sq}	-0.0898 (0.6494)	1.0000		Φ_{sq}	0.0662 (0.7379)	1.0000		Φ_{sq}	0.8833 (0.0000)	1.0000	
TC	∞	0.8853 (0.0000)	-0.2291 (0.2409)	1.0000	∞	0.8683 (0.0000)	-0.1050 (0.5948)	1.0000	∞	0.7362 (0.0008)	0.8126 (0.0001)	1.0000

Source: Author (SQ indicator), Clarkson (TC rate & SH prices)

P-values are given in the parenthesis

4.3.2 SQ Analysis for Dry Bulkers

The responsiveness of the dry bulker SQ indicator against the change in the market was shaped by the last 10-year average change of the TC rate and its proportion to the SH market prices. According to the mean-reverting approach, the long term average of the indicator was able to reflect the future cash flows assuming mean-reverting of the SH market prices (Caporin et al., 2012). Referring to this approach, in the dry bulker market, the SQ indicator is followed by the change in the TC rate and SH prices. This can be explained by various reasons; one of them is the less volatile price movements of the dry bulkers and less volatile demand for dry bulk services. UNCTAD (2003) plotted the growth of world seaborne trade in cargo ton-miles by cargo type. This clearly observed that dry bulk is less volatile than other cargo types. As illustrated in Figure 4.2, while the seaborne trade of tanker considerably fluctuates, the change in dry bulk is less volatile and smoothly changes.

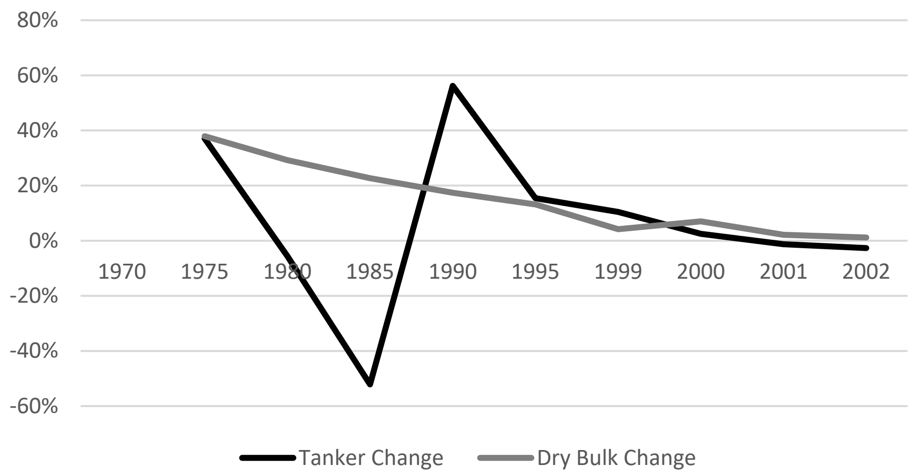


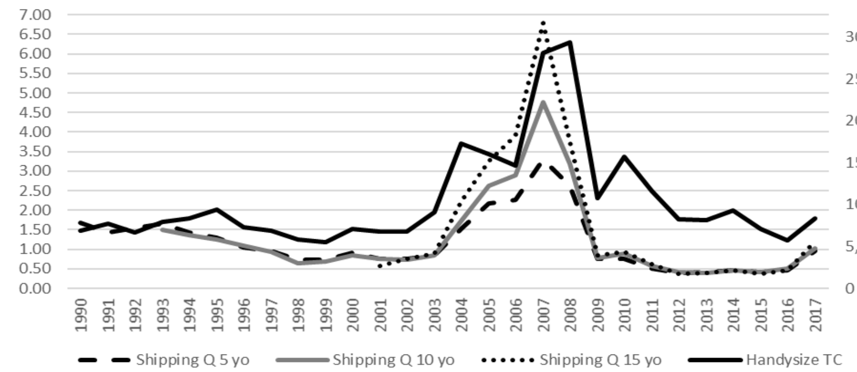
Figure 4.2. World Seaborne Trade in Ton-Miles Changes (1970-2002)

Source: UNCTAD

Moreover, the long-run price moves in the SH dry bulker market showed similar increasing and decreasing trends. This is highly linked to the common stochastic trend in price series (D. R. Glen, 1997), due to the fact that the world economic growth and the volume of international seaborne trade affect price series. However, the short term price movements of different dry bulkers were not identical. They showed different trends due to different demand for vessel size and the profitability of the freight market for each size (Alizadeh et al., 2010).

To consider the impact of the 2008 GFC on SQ, it is appropriate to interpret the SQ results within three-time sets: 1990-2003; 2003- 2008 and after 2008 GFC. As shown in Figure 4.3, from 1990 to 2003, SQ moved around the level of 0.80 to 2.00 for Handysize, Handymax, and Panamax; Capesize SQ started from around 1.60 and gradually decreases. The period between 2003 and 2008 witnessed historical peak levels in all shipping markets, which has resulted in an extremely high SQ indicator for all types of bulker vessels except Capesize. After the 2008 GFC, all SQ indicators have gone below level 1.00, which gives a strong buy signal until 2017. To illustrate the link between the SQ indicator and TC rate moves from a general perspective, in Figure 4.3, the TC rate was also included.

(a)



(b)

(c)

(d)

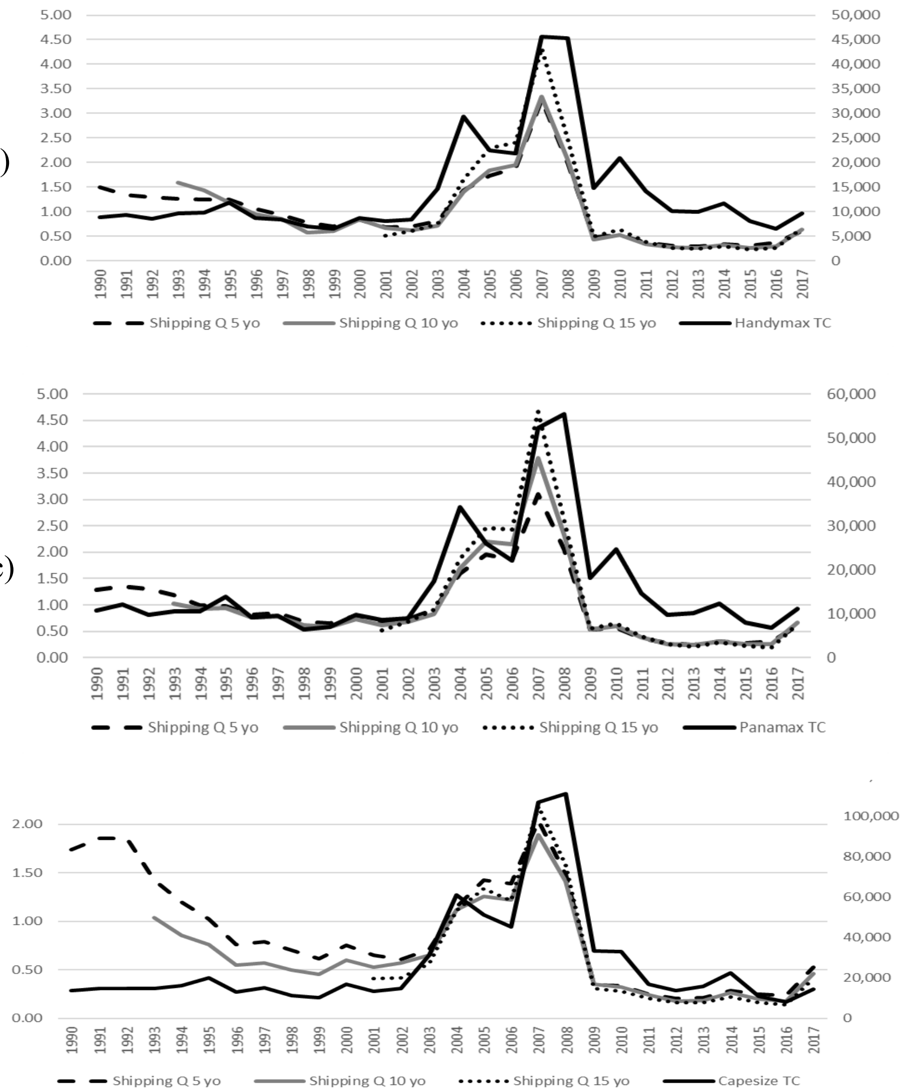


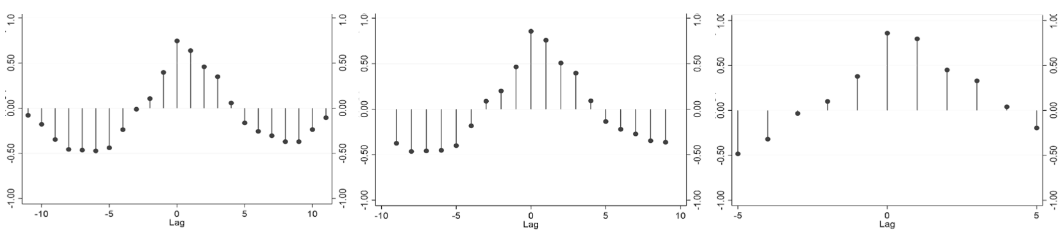
Figure 4.3. Calculated SQ Indicator for Bulker Carrier and Bulker TC Rate *(SQ indicator is on the left scale while time charter rate on the right scale)*. **(a)Handysize, (b) Handymax, (c) Panamax, (d) Capesize**

Source: Author (SQ indicator), Clarkson (TC rate)

From a general perspective, SQ indicator results for all vessel types indicated high volatility in the SH prices and TC rate markets. Narrowing down the interpretation of each vessel type. First, Handysize SQ_5, SQ_{10}, and SQ_{15} indicators were evaluated. As shown in Figure 4.3 (a), from 1990 to 2003, Handysize SQ_5 and SQ_{10} moved around the equilibrium level 1.00. From 2003 to 2008, Handysize SQ_5, SQ_{10}, and SQ_{15} showed an accelerated increase, which started from the level of 1.20 and reached out to the level of

6.80, while the responsiveness of SQ_{15} was sharper than SQ_5 and SQ_{10} for the given period. This may be due to the fact that 15-year-old SH Handysize became a more attractive investment alternative to take advantage of the high TC rate, while 5-year-old SH Handysize were less likely to be preferred at the first stage compared to 15-year-old Handysize, since the fact that older ships are less investment required than younger ships. Consequently, the excessive demand for 15-year-old SH Handysize triggered the ship prices far more than expected during 2003 and 2008. After 2008, SQ for all age groups indicated a similar ratio level, which ranged from 0.77 to 0.86 level until 2017. Also, the extreme volatility, from 0.70 to 6.80, of the SQ indicator can be explained by the fact that small vessels have higher operational flexibility than larger dry bulkers (Alizadeh et al., 2010), which led to high volatility in pricing small vessels. On the other hand, co-movement between the SQ indicator and TC rate can be observed during 1990 and 2017, which is also confirmed by the cross-correlation analysis shown in Figure 4.4. Figure 4.4 presented the cross-correlation between SQ indicator and TC rate, SQ indicator, and SH prices. It was observed that the time lag between Handysize SQ_5 and TC rate was less than 1-year, which can be interpreted as when the Handysize SQ_5 increased or decreased over a given period, within a year, the TC rate was most likely to increased or decreased. Also, the cross-correlation between Handysize SQ_{10} -TC rate and SQ_{15} -TC rate led a 1-year time-lag between variables. The cross-correlation between SQ_5 indicator and SH prices indicated the time lag was less than 1-year, whereas Handysize SQ10 -TC rate and SQ15 -TC rate had a 1-year time-lag between variables.

(a)



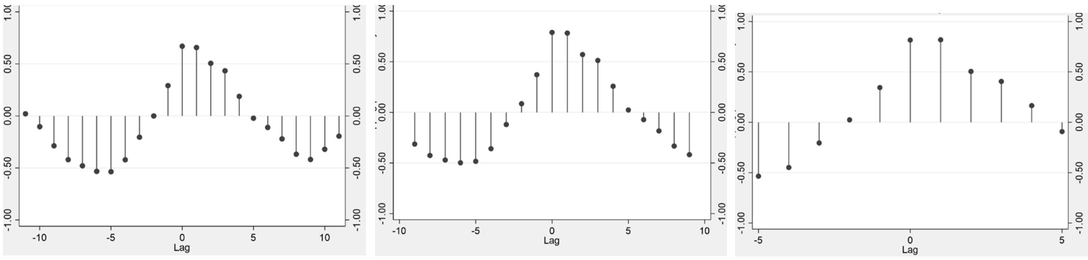
(b) 

Figure 4.4. Cross-Correlation Analysis *(left to right: 5, 10- and 15-year-old Handysize).* **(a) SQ Handysize and TC Rate, (b) SQ Handysize and SH Prices**

Source: Author (SQ indicator), Clarkson (TC rate)

Cross-correlations point to 5-7 months leading time-lag from shipping Q to time charter rates. When the SQ indicator hits over level 1.00, a charter rate decline follows after 5-7 months period. For illustrating this, a histogram of changes in time charter rates in corresponding time lags indicated by the highest cross-correlation has been created, as shown in Figure 4.5. For example, the SQ indicator turned to above level 1.00 during 2003 and 2004; the expectation was that the sell signal would dominate the market since second-hand price, and the time-charter rate would increase. Therefore, 2003-2004 period responses of these two indicators were presented in Figure 4.5 to illustrate the predictability of SQ indicator for the given period.

Furthermore, in this analysis, the movement of the SQ indicator, below level 1.00 and above level 1.00, was detected from 1990 to 2017, and the corresponding movement of TC rate and SH prices within specified time-lag with the correlation analysis was illustrated in Figure 4.5. This analysis aims to report the responsiveness of TC rate and SH prices against SQ indicator changes. As presented in Figure 4.5, in 1996, Handysize SQ_5 and SQ_{10} went over the level 1.00, and in 1997, the indicator went below level 1.00, which gave a buy signal. This means that the market price was expected to drop within one-year, and this created an opportunity to buy a ship. After the indicator went below level 1.00, in 1997, Handysize 5-year-old SH and 10-year-old SH lost value by 11% and 2%, respectively. At the same time, the TC rate had dropped by 22% in 1997. As shown in Figure 4.5, where SQ indicator turned to below level 1.00 (1996-1997;2008-2009), TC rate, and SH prices tend to decrease. Where the SQ indicator turned to above level 1.00 (2003-2004), TC rate and SH prices tend to increase. The analysis to test the responsiveness of TC rate and SH prices against SQ indicator changes majorly contributed to the reliability of the SQ indicator concerning the market changes. The analysis also showed that the SQ indicator could predict the freight and buy and sell market increases and decreases.

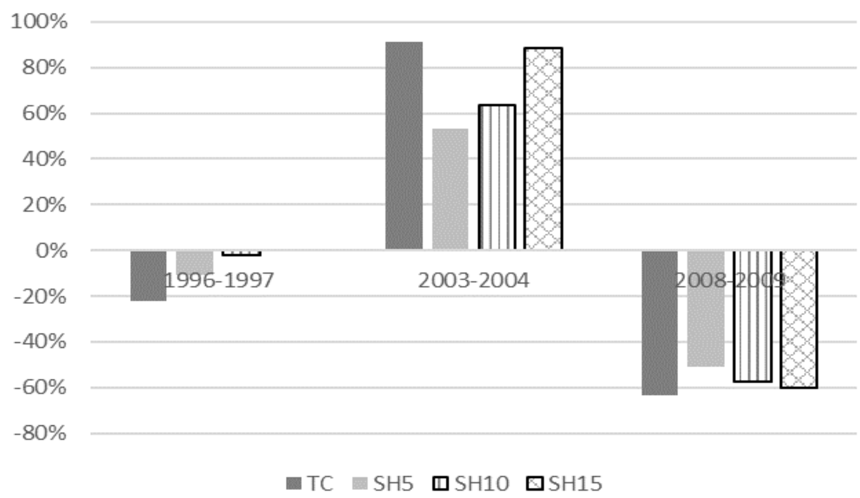


Figure 4.5. TC Rate and Handysize SH Prices Change After SQ Indicator Below/Above Level 1.00

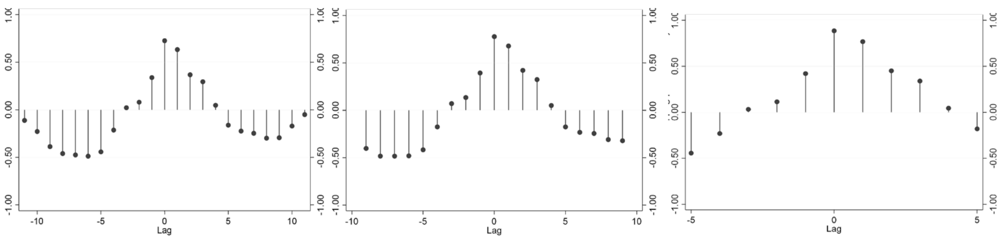
Source: Clarkson

Secondly, Handymax SQ_5, SQ_{10}, and SQ_{15} indicators were evaluated, as reported in Figure 4.3 (b). Handymax SQ showed a similar pattern with Handysize SQ; however, the gap among Handymax SQ indicators (5,10- and 15-year-old) at the peak level of the market in 2007 was narrower than Handysize SQ indicators (5,10- and 15-year-old). It showed that demand was volatile among the different age vessels, but not as much as what had occurred in Handysize vessels. Moreover, Handymax SQ_5 and SQ_{10} overlapped in 2007, while SQ_{15} reached the peak level at 4.30. It shows that older Handymax became a more attractive investment option for the investors from 2003 to 2008, aiming to enjoy the increased revenues as a consequence of increasing TC rate immediately. High demand for older Handymax led to higher SQ_{15} from 2003 to 2008. After 2008, SQ for all age groups decreased and moved around 0.50 level until 2017. Besides observing extreme peaks during 2003- 2008, the time period from 1990-2002 showed volatile moves of SQ indicators. Notably, in 1995, SQ_5 and SQ_{10} were over the level 1.00, where TC rate was also moved around 10,000 USD, which was above the last 10-year average of TC rate[14]. As per the logic of the SQ indicator, this technically signals for market increase; in other words, upcoming overvaluation in TC rates and SH prices and warn the market participants to take a position to sell their assets or stop investing. There are some solid reasons for the price increases in the market, for example, as UNCTAD (1995) reported the demand for Handymax has substantially increased, while the demand was significantly dropped for the 150K DWT dry bulk vessels. There might be other reasons to support this argument, such as new market entries as the demand for the vessel increases, increasing world trade growth, and increasing expectations. The crucial part, beyond the reasons, is to detect overvaluation and undervaluation of the second-hand prices. As the feature of SQ indicators is to summarize the previous information to predict future moves, it became possible to summarize that information technically and predict the future of the markets. The cross-correlation analysis and the corresponding changes of TC rate and SH prices against SQ indicator change analysis also supported the technical reliability of the SQ indicator.

[14] Average TC rate from 1985 to 1995 was 8,380 (Clarkson).

The cross-correlation analysis between Handymax $SQ_{5,10,15}$ and TC rate; and $SQ_{5,10,15}$ and SH prices were provided in Figure 4.6. The analysis showed that the changes in the SQ_5 and SQ_{15} were followed by the TC rate change in less than a year; the change in SQ_{10} was followed by the change in TC rate within 1-year. Also, the cross-correlation analysis between $SQ_{5,10,15}$ and SH prices indicated a 1-year time lag. The time-lag was used to interpret the corresponding changes of TC rate and SH prices against the changes of the SQ indicator in the following Figure 4.7.

(a)



(b)

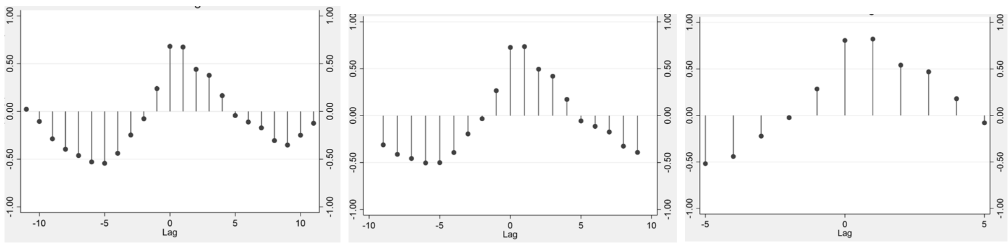


Figure 4.6. Cross-Correlation Analysis *(left to right: 5, 10-and 15-year-old Handymax).* **(a) SQ Handymax and TC Rate, (b) SQ Handymax and SH Prices**

Source: Author (SQ indicator), Clarkson(TC rate)

The analysis illustrates the corresponding change of TC rate and SH price changes in Handymax presented in Figure 4.7. The analysis demonstrated the movement of the SQ indicator was majorly followed by the TC rate and SH ship prices within the identified time-lag of 1-year, where the SQ indicator went below level 1.00, the TC rates and SH prices also decreased. For example, while all Handymax SQ indicators went above 1.00 level from 2003 to 2004, the TC rates doubled, and SH prices increased by more than 60%. Also, in 2009, the SQ indicators had dropped below 1.00 level, and consequently, Handymax TC rate and SH prices decreased by 50%. Although the impact of the responsiveness of TC rate and SH prices were not as strong as in 2003-2004 and 2008-2009, the decrease of TC rate and SH prices were recorded after the SQ indicator went below level 1.00 from 1995 to 1996.

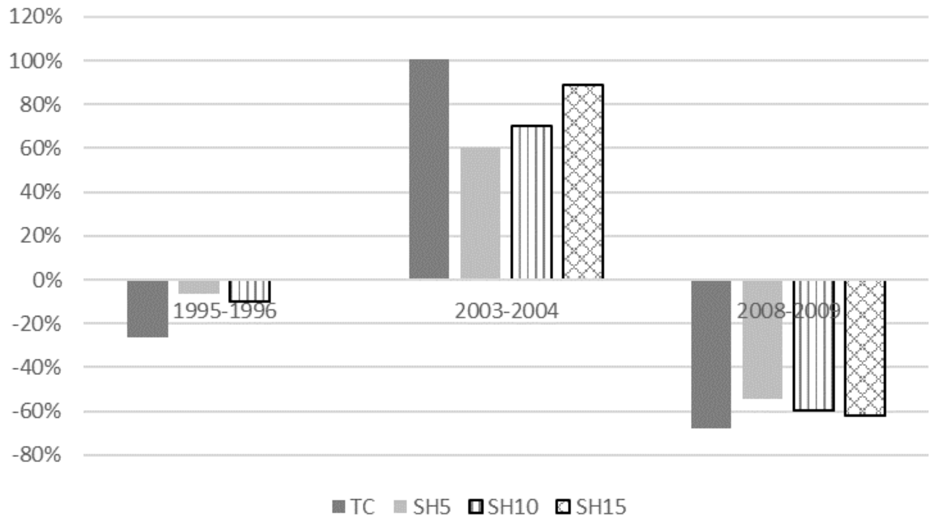


Figure 4.7. TC Rate and Handymax SH Prices Change After SQ Indicator Below/Above Level 1.00

Source: Clarkson

Thirdly, Panamax SQ5, SQ10, and SQ15 indicators were interpreted, as shown in Figure 4.3(c). Panamax SQ_5 and SQ_{10} were relatively smooth and moved around the equilibrium level from 1990 to 2003. During 2003 and 2008, SQ_5, SQ_{10}, and SQ_{15} became more volatile, which gave a sell signal. Especially, Panamax SQ_{15} firmly gave a sell signal during this period. After 2008, SQ for all age groups sharply decreased and went below 0.50 level. Until 2017, the signal steadily moved below 0.50 level and began increasing in 2017. This showed that the demand for Panamax, especially for older vessels, increased dramatically from 2003 to 2008. The use of Panamax has been boosted after mid-2002 by 2 million tons per month in grain shipment due to zero import duty advantages applied between the EU and Ukraine (UNCTAD, 2003). Furthermore, the worldwide demand for Panamax kept increasing in 2003 and 2004, where Panamax tonnage making up about 50 percent of contracts in most of the period. Besides the 2008 GFC period, from 1990 to 2002, the SQ indicator gave buy and sell signals throughout the period. Especially for the 5-year-old Panamax, the SQ indicator signaled for sell from 1990 to 1995 and it started giving a buy signal after 1995. From the 1990s to the end of the Gulf Crisis (1991), the expectation in the market turned to standby, and a specific decrease in newbuilding contracting in the 1990s occurred (UNCTAD, 1990), this consequently affected the buy and sell markets, therefore, sell signals from 1990 to 1995 were the consequences of the crisis in the Middle East. As emphasized in Handysize and Handymax evaluation, there are several different reasons explaining market volatility; the SQ indicator detects the overvaluations and undervaluations.

The cross-correlation analysis of Panamax $SQ_{5,10,15}$ and TC rate; and $SQ_{5,10,15}$ and SH were presented in Figure 4.8. The analysis of the SQ indicator and TC rate indicated that the changes in Panamax SQ_5, SQ_{10}, and SQ_{15} were mostly followed by the change in the TC rate within a year. Also, the time-lap between $SQ_{5,10,15}$ indicators and SH prices indicated were less than 1-year. The cross-correlation results were used to analyze the changes in the TC rate and SH Prices against the changes in the SQ indicator, as illustrated in Figure 4.9.

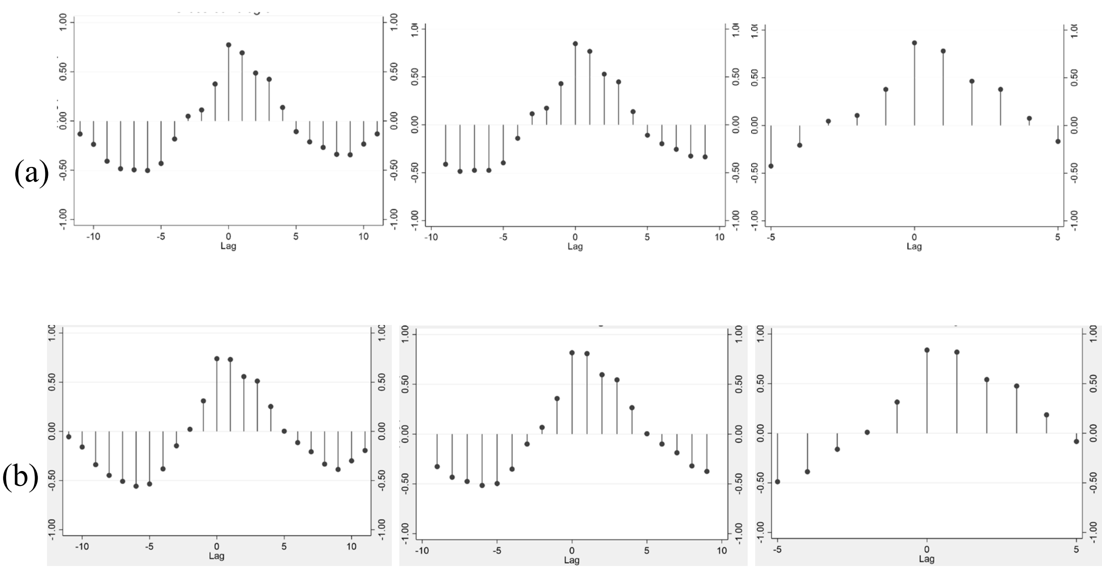


Figure 4.8. Cross-Correlation Analysis*(left to right: 5, 10- and 15-year-old Panamax).* **(a) SQ Panamax and TC Rate, (b) SQ Panamax and SH Prices**

Source: Author (SQ indicator), Clarkson (TC rate)

Further analysis of Panamax SQ indicators, TC rate, and SH prices reported in Figure 4.9. The analysis showed that the signals of SQ indicators were not indicative until 2003; for example, the SQ_5 indicator signaled for sell in 1993, but its impact observed weak in TC and SH, which is due to insufficient data. While Panamax 5-year-old SH prices were available to collect by 1976, 10- and 15-year-old, SH prices were available to collect by 1993 and 2001, respectively. This prevented the observation of the responsiveness of TC rate and SH price changes against SQ indicators change from 1993 to 1994. However, the responsiveness of Panamax TC rate and SH prices during the historical peak levels, 2003-2004 and 2008-2009, were observed. In 2003, while all Panamax SQ indicators turned to above level 1.00, TC rate and SH prices promptly responded. Also, in 2008, while the SQ indicator went below 1.00 level, TC rate and SH prices lost significant value, more than 60%.

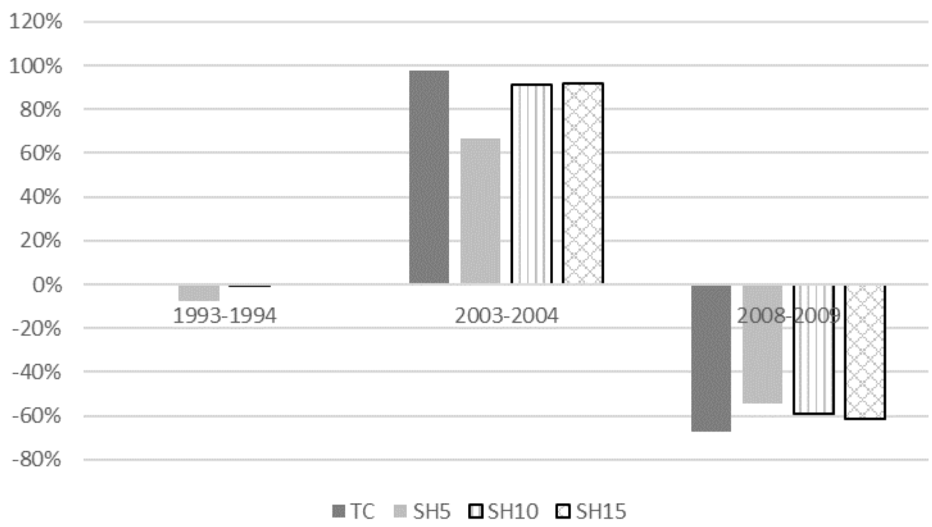


Figure 4.9. TC Rate and Panamax SH Prices Change After SQ Indicator Below/Above Level 1.00

Source: Clarkson

Fourthly and finally, Capesize SQ indicators were evaluated, as presented in Figure 4.3(d). At the beginning of 1990, Capesize SQ_5 showed an over-valuation signal, which moved around 1.60 level, and the indicator went below 1.00 after 1993. Until 2004, all indicators showed a buy signal. From 2004 to 2008, all Capesize SQ indicators gave a sell signal, but not strong as the other bulker vessel; the ratio never exceeded 2.18 level. Although the existing literature noted that prices of larger vessels are more volatile than smaller vessels (Alizadeh et al., 2010), as per the SQ indicator results, it was observed that the proportional volatility (market price to nominal price) was lower for the larger vessels compared to the smaller vessels, this might be due to high initial capital investment for the larger vessels than smaller ones. Also, according to the UNCTAD (2003, 2004) reports, Capesize and Panamax dry bulkers were the most preferred vessels during the reported period, due to the economies of scale. In particular, the need for larger vessels raised along with the increase in the demand for raw materials such as iron ore and coal (UNCTAD, 2009). From 2004 to 2008, the significant demand increase in steel production triggered the demand for a larger vessel, such as Capesize. Therefore, two major conditions affected the movement of the SQ indicator; first, the significant increase in demand for the larger vessels; and second, high initial capital investment in the larger vessels. While investors were keen to purchase the larger vessels during the peak period, which might lead to an extreme peak level in the SQ indicator, the high initial investment kept down the SQ indicator to go beyond a certain level.

The correlation analysis between Capesize $SQ_{5,10,15}$ and TC rate; and $SQ_{5,10,15}$ and SH presented in Figure 4.10. SQ_5 and TC indicated a 1-year time-lag, while the time lag was less than a year for SQ_{10} and SQ_{15}. While the cross-correlation between $SQ_{5,10}$ indicators and SH prices indicated for a 1-year time-lag, SQ_{15} indicator, and SH price indicated for less than a 1-year time-lag. The results of cross-correlation were used to analyze the changes in TC rate and SH prices against SQ indicators changes.

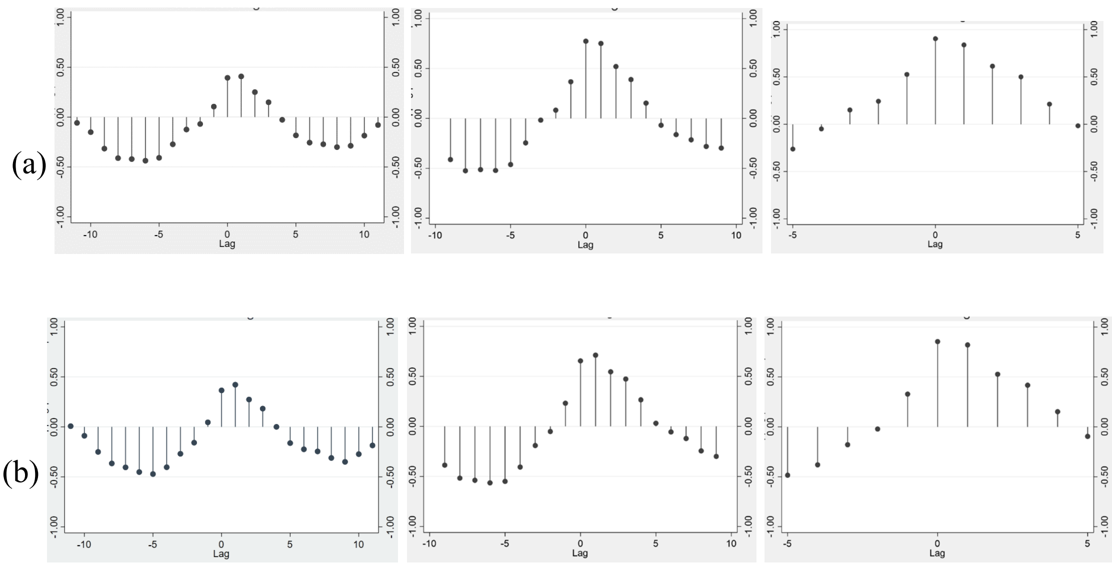


Figure 4.10. Cross-correlation Analysis *(left to right: 5, 10-and 15-year-old Capesize).* **(a) SQ Capesize and TC Rate, (b) SQ Capesize and SH Prices**

Source: Author (SQ indicator), Clarkson (TC rate)

The further analysis of the Capesize SQ indicator, TC rate, and SH prices was provided in Figure 4.11. The analysis stated a close link between the SQ indicator and TC rate and SH prices in various time intervals. The only exception is the period of 1993-1994, where Capesize SQ_{10} is above level 1.00, which signals for market overvaluation. The TC rate is increased by 11% in 1994 as expected. However, the SH prices of 10-year-old Capesize had dropped by 7%. Except for the 1993-1994 period, the rest of the SQ indicator move was followed by the TC rate and SH prices in the following year as expected.

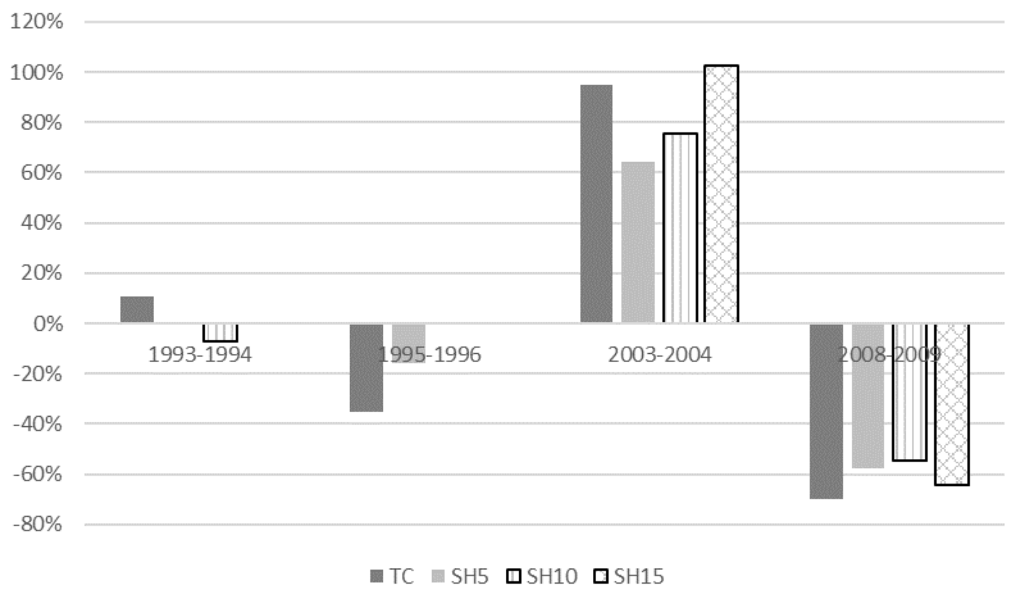


Figure 4.11. TC Rate and Capesize SH Prices Change After SQ Indicator Below/Above Level 1.00

Source: Clarkson

Overall, the SQ indicator results pointed out the changes in the TC rate, and SH prices can be traced with the changes in the SQ indicator. The SQ indicator analysis, along with cross-correlation analysis between the variables, was able to produce a rule-based market indicator. Notably, the functionality of the SQ indicator was observed from 2003 to 2008, where the historical peak and down levels occurred in TC and SH market, the older dry bulk vessels received a substantially higher demand than younger ship SQ indicator significantly captured the overvaluation during this period and gave a strong sell signal. Moreover, the cross-correlation analysis supported the predictability of the SQ indicator, where the changes in the SQ indicator signals were accurately predicted by TC rate and SH prices in dry bulk carriers.

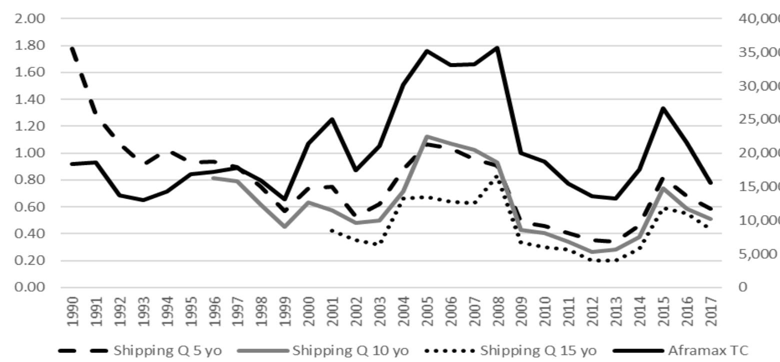
4.3.3 SQ Analysis for Tankers

The tanker markets, TC and SH, are highly exposed to external shocks and crises in the commodity market. For example, the impact of the Gulf Crisis between 1990-1991 has been profoundly felt in the tanker market after an extreme increase in oil prices, especially in larger vessel pricing and TC rates. As observed in Figure 4.12, tanker freight rates started to improve in 1995 (UNCTAD, 1995). Due to the unexpected oil shock, the SQ indicator, TC rate, and SH prices did not move in the same direction, and the correlation between these two variables was negative from 1990 to 1995. While the SQ indicator for all vessel types signaled for sell the ship in 1990 due to overvaluation in the market, TC rate and SH prices did not move in the expected direction within the specified time-lag. After 1995, the correlation between the SQ indicator and TC rate, as well as the SQ indicator and SH prices, started to turn out to be positive and stronger.

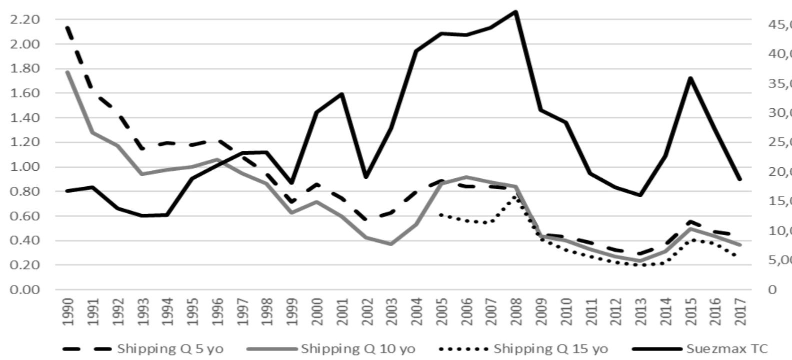
The buy and sell signals of tanker SQ indicator for all age and vessel types typically stayed below level 1.00. This can be explained by the inelastic demand of the product, mainly inelastic demand for oil product. From a general perspective, SQ indicator results for tanker vessels moved in a narrow range, 0.20 to 2.80, but showed a volatile trend. The SQ indicator did not only react to the 2008 GFC, but it has also reacted to the Gulf Crisis between 1990-1991 and the energy crisis in the 2000s (Van de Ven et al., 2017). In the below analysis, SQ indicator results were interpreted for the Product tanker, Aframax, Suezmax, and VLCC, Panamax was excluded due to the unavailability of SH prices. Firstly, the product tanker SQ indicator was evaluated, as shown in Figure 4.12 (a). From the period of 1990 to 2003, while the SQ_{10} indicator moved in a band of 0.60 to 1.00, SQ_5 started with a highly "sell" signal, from the level 1.40, and gradually decreased to 0.50 level.

(a)

(b)



(c)



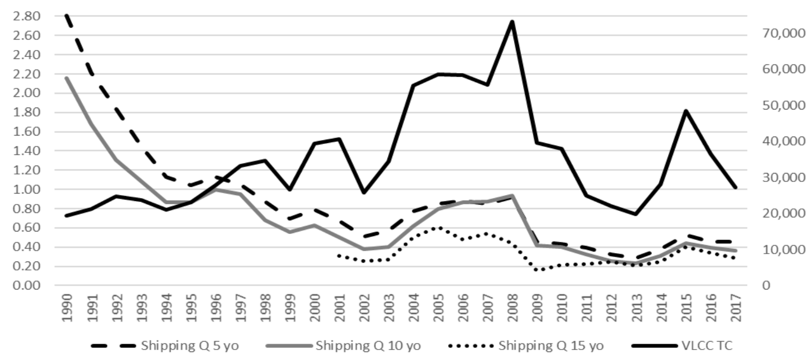
(d) 

Figure 4.12 Calculated SQ Indicator for Tanker Carrier and Tanker TC Rate *(SQ ratio is on the left scale while time charter rate on the right scale)* **(a)Product tanker, (b)Aframax, (c)Suezmax, (d) VLCC**

Source: Authors (SQ indicator), Clarkson (TC rate)

For example, in 1990, while the calculated value of a 5-year-old product tanker was 15M USD, the market price was 21M USD, and the SQ indicator was 1.38, which indicates strong sell. In 1992, while SH product tanker prices decreased by 14%, the SQ indicator started giving buy signal with going below 0.90 level. This volatile pattern clearly showed the impact of the oil crisis, where the demand highly fluctuated. Consequently, it was observed with the SQ indicator. From 2003 to 2008, product tanker SQ_5, SQ_{10}, and SQ_{15} indicators strongly responded to the 2008 GFC, where the SQ indicator significantly exceeded level 1.00. From the beginning of 2003, SQ_5, SQ_{10}, and SQ_{15} were showing an increasing trend and sharply turned to a decreasing trend by the end of 2007 for each age group of the product tanker. In the post-crisis era, SQ_5 was more likely to turn to sell signal, which pushed the limit through equilibrium point 1.00. During 2010 and 2014, product tanker SQ_5 increased the gap between SQ_{10}, which showed that the demand for SH_5 significantly increased after the crisis period, which affected its market price in the upturn.

The cross-correlation between SQ_5 and SQ_{10} and TC rate and SH prices indicated a weak correlation, as shown in Figure 4.13. However, the cross-correlation between SQ_{15}, and

TC rate and SH prices were relatively higher, and cross-correlation analysis indicates that the time lag is less than a year. After having weak results from the yearly SQ indicator data, the cross-correlation analysis was revised in monthly analysis to improve the results.

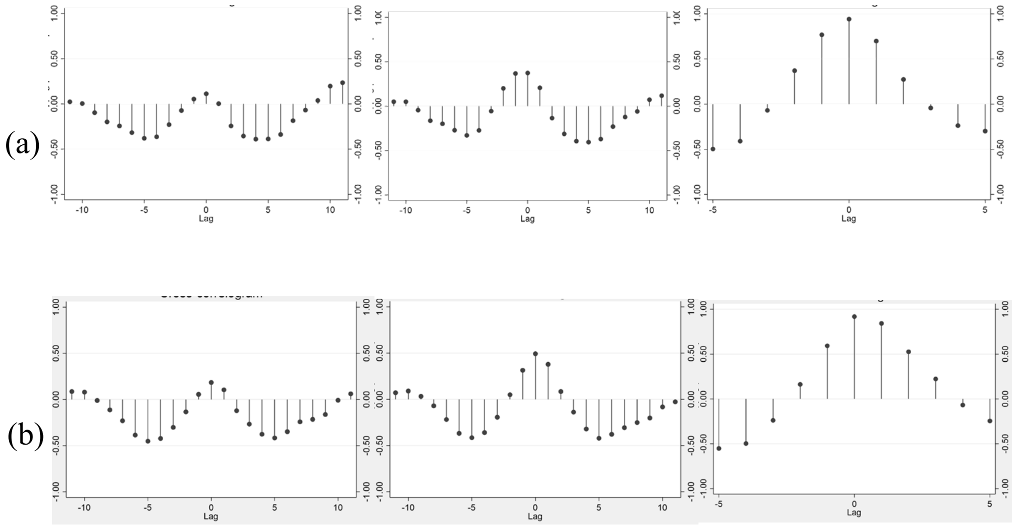


Figure 4.13. Cross-correlation Analysis *(left to right: 5, 10- and 15-year-old Product Tanker).* **(a) SQ Product Tanker and TC Rate, (b) SQ Product Tanker and SH Prices**

Source: Author (SQ indicator), Clarkson (TC rate)

Although the correlation analysis is weak between variables, the cross-correlation analysis indicated precise results in terms of the indicator changes. As shown in Figure 4.14, where the SQ indicator was below 0.90 level[15], TC and SH had dropped accordingly. The only exception was the TC rate in 1991; it did not drop as expected, and instead increased by 3%. From 2005-2006, where the SQ indicator was above equilibrium, the TC rate and SH prices increased by more than 10%. The price change

[15] For tanker vessels, the equilibrium level is taken as 0.90, since the indicator mostly do not exceed 1.00 level.

analysis supported the reliability of the SQ indicator to predict the future movement of the TC rate and SH prices in the tanker market.

Secondly, the outcome of Aframax SQ indicators was analysed, as shown in Figure 4.12(b). Aframax SQ indicators showed a volatile trend over the sample period, especially, Aframax SQ_5 gave signal around 1.80 level in 1990, when 5-year-old SH price was 35M USD, whereas the calculated value of the SH price was 20M USD. The uncertainty of asset value leads to higher SQ indicator results and indicates the gap between the market prices and the nominal prices.

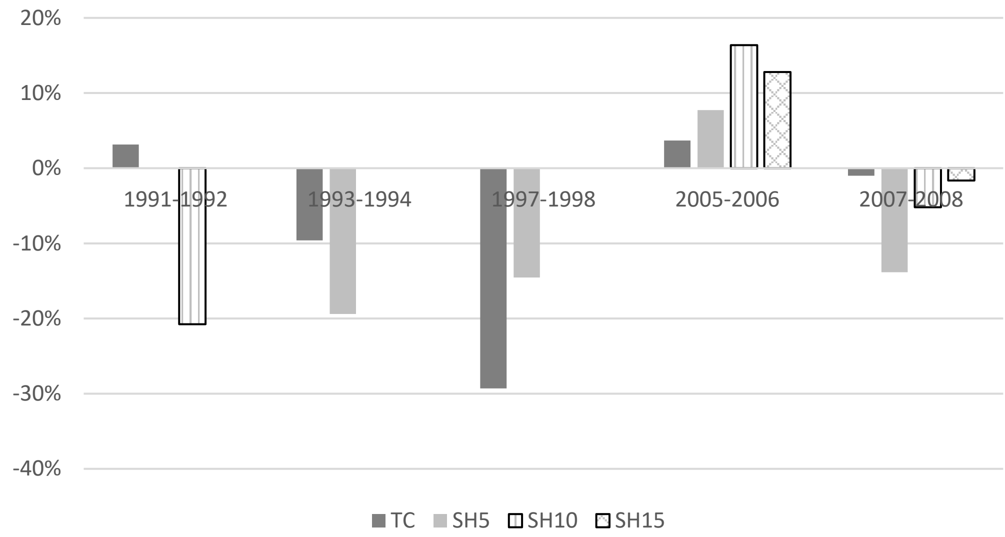


Figure 4.14. TC Rate and Product Tanker SH Prices Change After SQ Indicator Below/Above Level 1.00

Source: Clarkson

The Aframax SQ_{10} indicator moved in the band of 0.40 and 0.80 from 1995 to 2003, where the indicator mostly stayed below 0.80 level. Having a closer look into the Aframax market prices and the SQ indicator, it was observed that although the calculated value of 10-year-old Aframax was volatile in accordance with TC rate changes, the market price of the vessel was quite steady. Therefore, the SQ indicator has not moved above 0.80 level until 2003. Aframax SQ_{15} notably demonstrated a highly volatile trend throughout the crisis period, which indicates that the demand for Aframax was highly volatile. Especially in the time of peak level of freight rate, Aframax ships might have been preferred by investors who were still keen to invest in the market with lower-priced ships. Considering the increasing trend of TC rate, the investor would be keen to bear the risk of having older but cheaper ships to catch up with the flourished revenues. Therefore, Aframax SQ_{15} was more volatile compared to younger vessels. After 2008, the ratio for all age group vessels significantly had dropped until 2015. From 2015 to 2017, after short term increase, the SQ indicator for all age group started falling.

The cross-correlation between SQ indicator and TC rate; and SQ indicator and SH prices were presented in Figure 4.15. The cross-correlation between SQ_5 and both TC rate and SH prices were quite weak. However, the highest point, 5-year, was accepted as a time lag to be used in the following analysis. The cross-correlation between SQ_{10} and SQ_{15} showed that the TC rate and SH prices were high and indicated less than a 1-year time-lag between SQ and the variables.

(a)

(b)

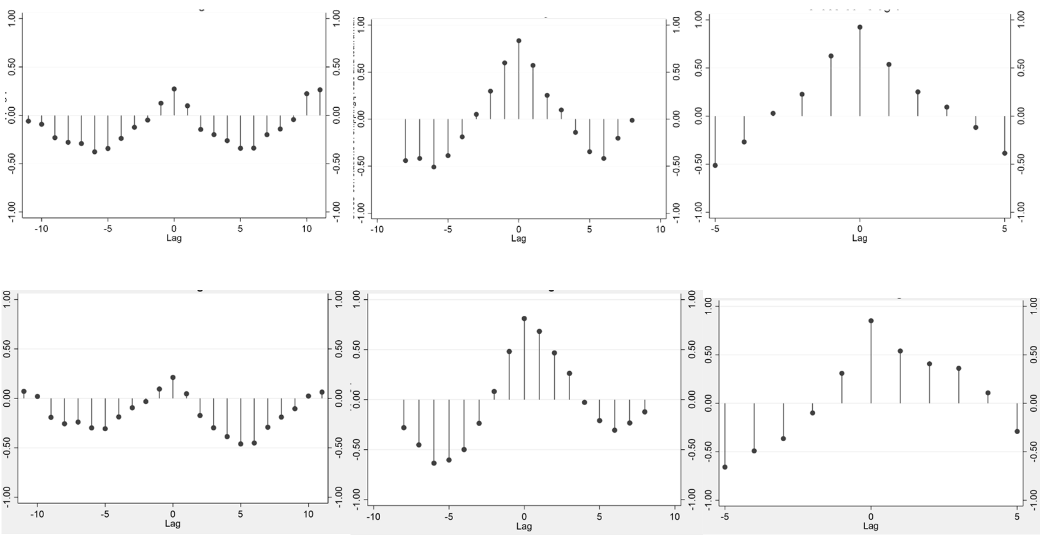


Figure 4.15. Cross-correlation Analysis *(left to right: 5, 10-and 15-year-old Aframax).* **(a) SQ Aframax and TC Rate, (b) SQ Aframax and SH Prices**

Source: Author (SQ indicator), Clarkson (TC rate)

The analysis in Figure 4.16 demonstrated the change in TC rate and SH prices following the change in Aframax SQ indicators. Figure 4.16 showed that while $SQ_{5,10,15}$ indicators were below 0.90 level (1996-1997; 2008-2009), the TC rate and SH prices lost value as per the specified time lag. The only exception is TC change in 2004-2005, where the SQ indicator signaled for the market price increase, but the TC rate had dropped by 6%.

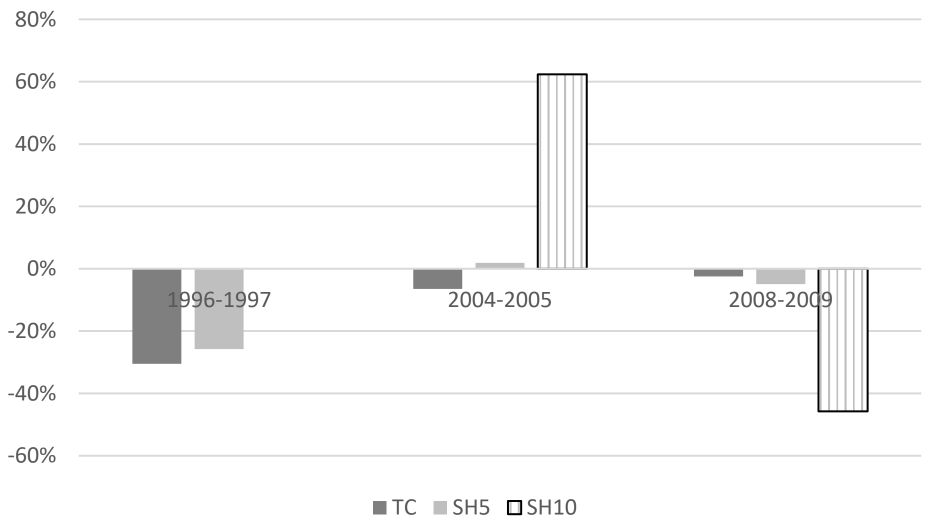
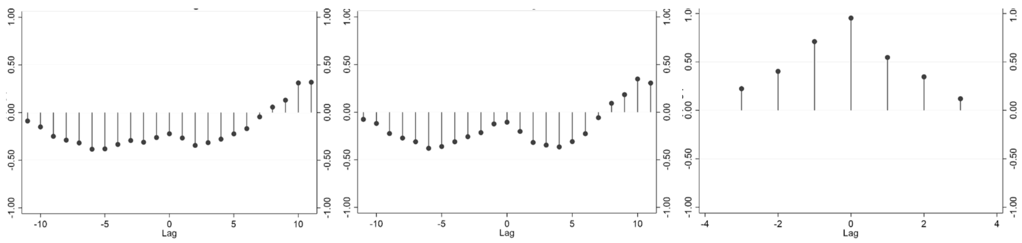


Figure 4.16. TC Rate and Aframax SH Prices change after SQ Indicator Below/Above Level 1.00

Source: Clarkson

Thirdly, Suezmax SQ indicators were evaluated, as reported in Figure 4.12(c). In general, SQ indicators moved in the same direction as the other vessel types. SQ_5 and SQ_{10} indicators were strongly signaled for sell in 1990, which was around 2.20 level and 1.80 level, respectively, and both indicators gradually decreased until 2002. The demand for Suezmax was highly volatile in 1995, which directly affected the SQ indicator. In 1997, reports showed that the demand for Suezmax started increasing due to the accelerated oil production in Nigeria (UNCTAD, 1997). Notably, from 2011 to 2014, the SQ indicator for all age groups strongly signaled for buy, due to consistent price drops in SH and highly volatile TC rates. The correlation between SQ_5, SQ_{10}, and TC rate and SH prices was quite weak and negative, as shown in Figure 4.17. The weak correlation was the result of price shocks at the beginning of the 1990s, as the market prices reacted to the crises. However, there was a positive and robust correlation between SQ_{15} and TC rate; and SQ_{15} and SH prices. As a consequence of the cross-correlation analysis, the time lag indicated for SQ_5 and SQ_{10} with TC rate was 5-and 6-year, respectively, while SQ_5 and SQ_{10} with SH rate were 4-and 5-year respectively. SQ_{15} and TC rate; and SQ_{15} and SH prices time lag were less than 1-year.

(a)



(b)

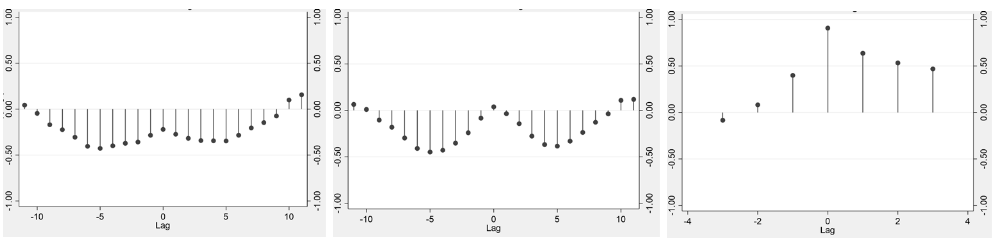


Figure 4.17. Cross-correlation Analysis *(left to right: 5, 10-and 15-year-old Suezmax).* **(a) SQ Suezmax and TC Rate, (b) SQ Suezmax and SH Prices**

Source: Author (SQ indicator), Clarkson (TC rate)

Figure 4.18 illustrated the reaction of TC rate and SH prices against the change in the SQ indicator. Generally, it was observed that the SQ indicator signals for all Suezmax vessels followed by TC and SH from 1992 to 1998. After 1998, Suezmax SQ_5, SQ_{10}, and SQ_{15} indicators have steadily stayed below the equilibrium level. The SQ indicator also did not reach 0.90 level for 15-year-old Suezmax; therefore, it is not reported in Figure 4.18.

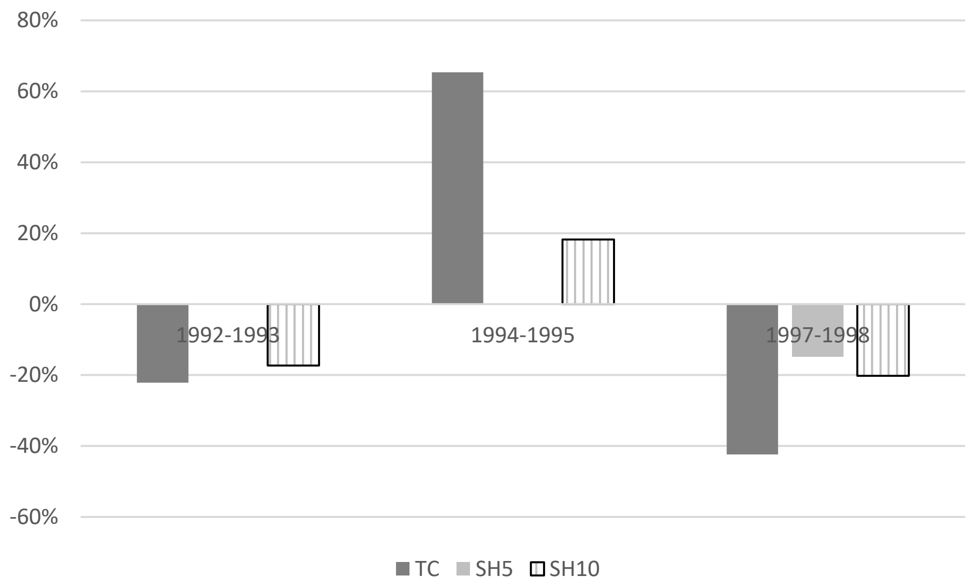


Figure 4.18. TC Rate and Suezmax SH Prices Change After SQ Indicator Below/Above Level 1.00

Source: Clarkson

Fourthly and finally, VLCC SQ indicators were analysed, as shown in Figure 4.12(d). As observed in other tanker vessels, SQ_5 started with the sell signal in 1990s and gradually decreased until 1999. VLCC TC rate showed several price downs and ups before the 2008 GFC, which also proportionally affected the movement of the SQ indicators. In general, the SQ_5, SQ_{10}, and SQ_{15} indicators tend to stay below 0.90 level, and they moved in a more steady trend. They ranged in the line between 0.50 and 1.00 level. VLCC SQ indicators signals never turned to sell before, and after GFC, in 2007, it slightly converged to sell level, 1.00, but then turned to buy signal.

The correlation between SQ_5, SQ_{10}, and TC rate and SH prices was quite weak and negative, as shown in Figure 4.19, which is due to price shocks in the tanker market. The time-lag between SQ_5, SQ_{10}, and SH prices was 5-years, while SQ_5, SQ_{10}, and TC rate indicated for 4-years. The cross-correlation between SQ_{15} and TC rate, as well as SQ_{15} and SH prices, were positive and strong. The time-lag between SQ_{15} with TC rate and SH prices were less than 1-year.

(a)

(b)

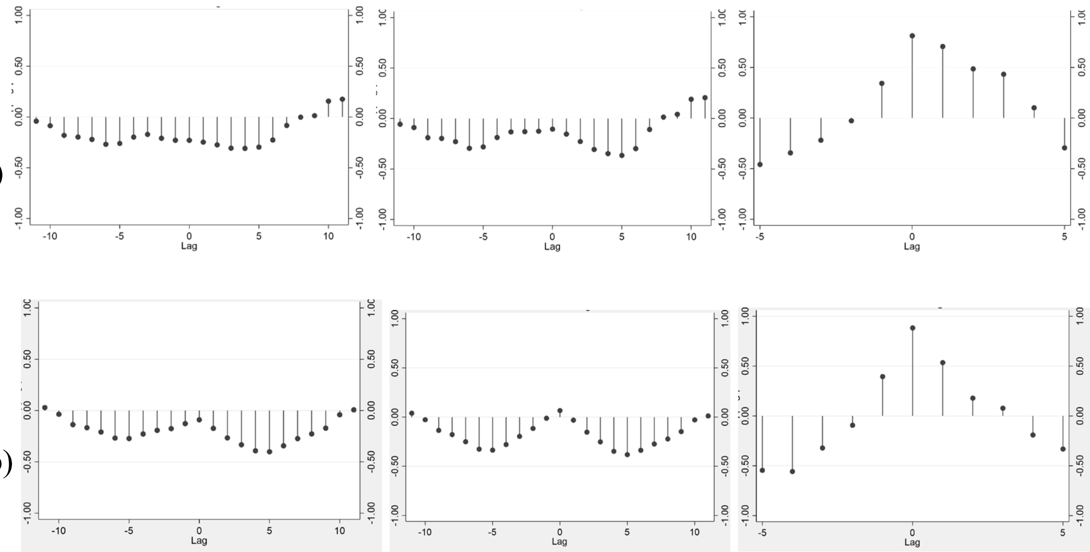


Figure 4.19. Cross-correlation Analysis *(left to right: 5, 10- and 15-year-old VLCC).* **(a) SQ VLCC and TC Rate, (b) SQ VLCC and SH Prices**

Source: Author (SQ indicator), Clarkson (TC rate)

Figure 4.20 displayed the changes in TC rate and SH prices against the VLCC SQ indicator change. The figures showed that the changes in the indicator were consequently followed by TC and SH; the only exception is TC (2004-2005), it was dropped by 6%, although it was expected to increase according to the indicator.

Overall, in Aframax, Suezmax, and VLCC, although TC rate showed an extreme increase from 2003 to 2004, representing an increase of 44%,48%, and 61% respectively, their SQ indices did not increase as product tanker increased. This shows that the market value of an asset did not show an extreme increase, although the expected revenue of the asset significantly increased as correlation analysis supported this assumption that the link between the TC rate and SQ were quite weak.

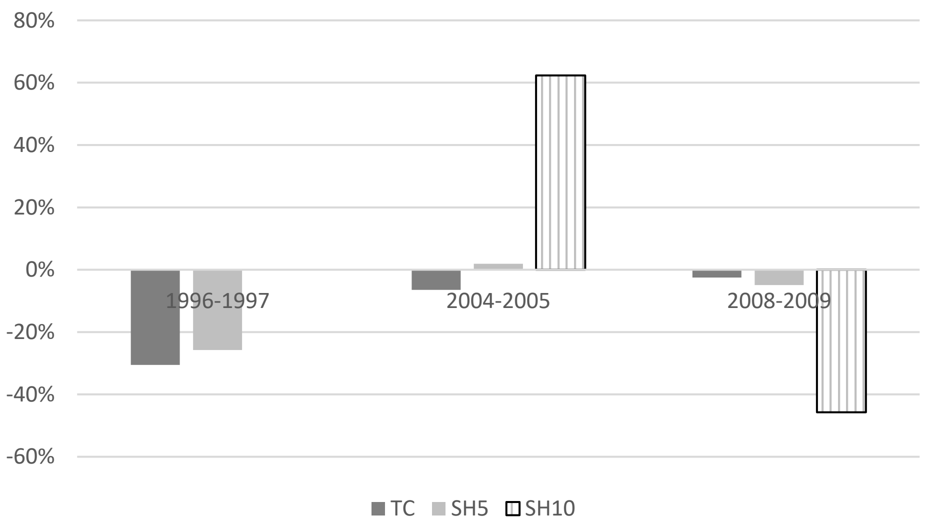


Figure 4.20. TC Rate and VLCC SH Prices Change after SQ Indicator Below/Above Level 1.00

Source: Clarkson

4.4 Monthly Results of the SQ

The monthly SQ results are provided for both dry bulk carriers and tankers. In addition to the presentation of the results, descriptive statistics and correlation analysis have also been applied to investigate the link between SQ, TC rate, and SH prices. Since TC rate and SH ship prices are reliable market indicators for future asset management (Haralambides et al., 2005), it is expedient to compare SQ with these two variables to identify its correlation with the markets. Moreover, the time lags between SQ and TC rate, SQ, and SH prices are also provided to understand the time-lag period between variables. As a consequence of the cross-correlation analysis, it is expected to obtain a more precise link between variables regarding the timing of their movements.

4.4.1 Descriptive Statistics

Table 4.4 reports descriptive statistics of monthly TC rates, SH prices, and SQ for dry bulk carriers and tankers. While the TC rate and SH prices have not shown a significant difference between monthly and yearly analysis, the monthly descriptive results of the SQ indicator has shown a considerable increase in mean and standard deviation. The mean of the monthly SQ indicated that it ranged between 0.91 and 1.96 for dry bulk carriers, and 0.22 and 0.77 for tankers. Comparing to the yearly results, the mean of the SQ is considerably higher in the monthly sample since monthly SQ reflects short term fluctuations. In the yearly sample, short term fluctuations were neutralized. The standard deviation of SQ has also significantly increased in the monthly analysis. While it was around 1% for both dry bulk carriers and tankers, it ranged between 56% and 162% for dry bulk carriers, and 9% and 59% for tankers. The volatile market prices (TC rate, SH prices) in the shipping industry were also observed through the descriptive statistic results. The skewness and kurtosis of the monthly samples have increased compared to the yearly results; the sample data showed asymmetric distribution.

Correlation analysis of monthly data was also presented for TC rate, SH prices, and SQ indicator of dry bulk carriers in Table 4.5. The correlation coefficients between SQ and SH and TC were mostly high, except for Handysize SQ_{15}, which was slightly lower than other vessels. Comparing to yearly results of dry bulk carriers, monthly correlations were considerably higher and significant. As SQ increased, TC rates and SH prices increased. In other words, the nominal price of a ship decreased and gave a signal for sell, since the market price of the ship was overvalued than the calculated nominal price of the ship. The cross-correlation results support the strong link between variables.

Table 4.4. Descriptive Statistics of Output and Input Variables for Monthly SQ (1990-2017)

Bulker/Handysize$_5$		Mean	Standard deviations	Skewness	Kurtosis	Tanker/ Product$_5$		Mean	Standard deviations	Skewness	Kurtosis
SH$_5$	β_5	14.502	8.515	1.865	8.103	SH$_5$	β_5	21.557	9.672	1.058	4.213
SQ	Φ_{sq}	1.401	0.749	1.533	4.996	SQ	Φ_{sq}	0.604	0.226	0.988	3.767
TC	∞	8,858.70	6,110.07	2.961	13.501	TC	∞	13,339.38	5,495.32	0.908	3.752
Bulker/Handysize$_{10}$						Tanker/ Product$_{10}$					
SH$_{10}$	β_{10}	14.264	8.194	2.033	7.470	SH$_{10}$	β_{10}	17.49547	7.368264	1.829375	5.580079
SQ	Φ_{sq}	1.960	1.461	1.390	4.432	SQ	Φ_{sq}	0.508	0.185	0.990	3.479
TC	∞	8,858.70	6,110.07	2.961	13.501	TC	∞	13,339.38	5,495.32	0.908	3.752
Bulker/Handysize$_{15}$						Tanker/ Product$_{15}$					
SH$_{15}$	β_{15}	12.033	7.634	1.573	5.414	SH$_{15}$	β_{15}	14.893	6.710	1.195	3.063
SQ	Φ_{sq}	1.562	2.795	2.469	14.242	SQ	Φ_{sq}	0.353	0.141	0.710	2.059
TC	∞	8,858.70	6,110.07	2.961	13.501	TC	∞	13,339.38	5,495.32	0.908	3.752
Bulker/Handymax$_5$						Tanker/ Aframax$_5$					
SH$_5$	β_5	21.753	12.143	2.529	10.534	SH$_5$	β_5	31.317	16.103	0.674	3.230
SQ	Φ_{sq}	1.133	0.758	4.427	10.191	SQ	Φ_{sq}	0.674	0.294	1.571	6.097
TC	∞	13,144.73	10,907.74	2.868	11.795	TC	∞	16,621.42	8,568.87	0.789	3.270

Bulker/Handymax$_{10}$					
SH$_{10}$	β_{10}	17.771	11.230	2.377	8.969
SQ	Φ_{sq}	1.255	1.050	2.433	8.524
TC	∞	13,144.73	10,907.74	2.868	11.795
Bulker/Handymax$_{15}$					
SH$_{15}$	β_{15}	15.342	10.754	1.857	6.313
SQ	Φ_{sq}	1.855	1.618	1.847	5.808
TC	∞	13,144.73	10,907.74	2.868	11.795
Bulker/Panamax$_{5}$					
SH$_{5}$	β_{5}	21.690	14.51	2.535	11.219
SQ	Φ_{sq}	1.052	0.651	2.223	7.817
TC	∞	13,407.25	12,349.51	3.251	15.011
Bulker/Panamax$_{10}$					
SH$_{10}$	β_{10}	20.829	14.236	2.367	8.815
SQ	Φ_{sq}	1.168	0.956	2.241	7.602
TC	∞	13,407.25	12,349.51	3.251	15.011
Bulker/Panamax$_{15}$					
SH$_{15}$	β_{15}	17.744	13.392	1.881	6.309
SQ	Φ_{sq}	1.669	1.504	1.831	5.769

Tanker/ Aframax$_{10}$					
SH$_{10}$	β_{10}	29.493	12.921	1.283	3.405
SQ	Φ_{sq}	0.518	0.186	0.451	2.198
TC	∞	16,621.42	8,568.87	0.789	3.270
Tanker/ Aframax$_{15}$					
SH$_{15}$	β_{15}	17.096	7.3848	1.521	5.838
SQ	Φ_{sq}	0.288	0.106	0.587	3.155
TC	∞	16,621.42	8,568.87	0.789	3.270
Tanker/ Suezmax$_{5}$					
SH$_{5}$	β_{5}	42.440	20.989	0.513	3.422
SQ	Φ_{sq}	0.709	0.379	1.555	5.475
TC	∞	21,236.57	11,898.82	0.881	2.989
Tanker/ Suezmax$_{10}$					
SH$_{10}$	β_{10}	35.906	15.801	1.604	4.634
SQ	Φ_{sq}	0.624	0.327	1.288	4.848
TC	∞	21,236.57	11,898.82	0.881	2.989
Tanker/ Suezmax$_{15}$					
SH$_{15}$	β_{15}	25.860	10.231	1.529	5.963
SQ	Φ_{sq}	0.265	0.100	1.212	4.873

TC	∞	13,407.25	12,349.51	3.251	15.011	TC	∞	21,236.57	11,898.82	0.881	2.989
Bulker/$Capesize_5$						Tanker/ $VLCC_5$					
SH_5	β_5	36.503	24.744	2.696	12.022	SH_5	β_5	57.236	32.951	0.508	3.353
SQ	Φ_{sq}	0.901	0.560	1.765	5.917	SQ	Φ_{sq}	0.773	0.591	2.410	8.711
TC	∞	21,521.43	25,842.84	3.476	16.445	TC	∞	26,886.51	17,426.60	0.969	3.635
Bulker/$Capesize_{10}$						Tanker/ $VLCC_{10}$					
SH_{10}	β_{10}	31.199	21.517	2.243	8.136	SH_{10}	β_{10}	51.569	22.651	1.793	5.715
SQ	Φ_{sq}	0.755	0.577	2.334	8.028	SQ	Φ_{sq}	0.649	0.464	2.263	8.372
TC	∞	21,521.43	25,842.84	3.476	16.445	TC	∞	26,886.51	17,426.60	0.969	3.635
Bulker/$Capesize_{15}$						Tanker/ $VLCC_{15}$					
SH_{15}	β_{15}	26.214	20.577	1.955	6.321	SH_{15}	β_{15}	29.844	10.717	0.663	2.775
SQ	Φ_{sq}	0.905	0.849	1.926	5.925	SQ	Φ_{sq}	0.224	0.085	0.764	3.044
TC	∞	21,521.43	25,842.84	3.476	16.445	TC	∞	26,886.51	17,426.60	0.969	3.635

Source: Author (SQ indicator), Clarkson (TC rate & SH prices)

Table 4.5 Correlation Matrix of Dry Bulker Carrier TC Rate, SH Prices, and SQ (1990-2017)

Handysize$_5$		β_5	Φ_{sq}	∞	Handysize$_{10}$	β_{10}	Φ_{sq}	∞	Handysize$_{15}$	β_{15}	Φ_{sq}	∞
SH$_5$	β_5	1.0000			β_{10}	1.0000			β_{15}	1.0000		
SQ	Φ_{sq}	0.8649 (0.0000)	1.0000		Φ_{sq}	0.8581 (0.0000)	1.0000		Φ_{sq}	0.5800 (0.0000)	1.0000	
TC	∞	0.9375 (0.0000)	0.8235 (0.0000)	1.0000	∞	0.9447 (0.0000)	0.8041 (0.0000)	1.0000	∞	0.9516 (0.0000)	0.5216 (0.0000)	1.0000
Handymax$_5$		β_5	Φ_{sq}	∞	Handymax$_{10}$	β_{10}	Φ_{sq}	∞	Handymax$_{15}$	β_{15}	Φ_{sq}	∞
SH$_5$	β_5	1.0000			β_{10}	1.0000			β_{15}	1.0000		
SQ	Φ_{sq}	0.9453 (0.0000)	1.0000		Φ_{sq}	0.9638 (0.0000)	1.0000		Φ_{sq}	0.9676 (0.0000)	1.0000	
TC	∞	0.9483 (0.0000)	0.9163 (0.0000)	1.0000	∞	0.9488 (0.0000)	0.9324 (0.0000)	1.0000	∞	0.9448 (0.0000)	0.9242 (0.0000)	1.0000
Panamax$_5$		β_5	Φ_{sq}	∞	Panamax$_{10}$	β_{10}	Φ_{sq}	∞	Panamax$_{15}$	β_{15}	Φ_{sq}	∞
SH$_5$	β_5	1.0000			β_{10}	1.0000			β_{15}	1.0000		
SQ	Φ_{sq}	0.9283	1.0000		Φ_{sq}	0.9346	1.0000		Φ_{sq}	0.9726	1.0000	

		(0.0000)				(0.0000)				(0.0000)		
TC	∞	0.9586 (0.0000)	0.8959 (0.0000)	1.0000	∞	0.9548 (0.0000)	0.9082 (0.0000)	1.0000	∞	0.9554 (0.0000)	0.9255 (0.0000)	1.0000
$Capesize_5$		β_5	Φ_{sq}	∞	$Capesize_{10}$	β_{10}	Φ_{sq}	∞	$Capesize_{15}$	β_{15}	Φ_{sq}	∞
SH_5	β_5	1.0000			β_{10}	1.0000			β_{15}	1.0000		
SQ	Φ_{sq}	0.8184 (0.0000)	1.000		Φ_{sq}	0.9575 (0.0000)	1.0000		Φ_{sq}	0.9876 (0.0000)	1.0000	
TC	∞	0.9560 (0.0000)	0.7897 (0.0000)	1.000	∞	0.9526 (0.0000)	0.9540 (0.0000)	1.0000	∞	0.9675 (0.0000)	0.9620 (0.0000)	1.0000

Source: Author (SQ indicator), Clarkson (TC rate & SH prices)

P-values are given in the parenthesis

Table 4.6 reported monthly correlation analysis of TC rate, SH prices, and the SQ indicator of tanker carriers. The low and insignificant results in yearly tanker correlation were considered, and therefore, the sample was tested between 1996 and 2017. Referring to Figure 4.17, the correlation between the SQ indicator and TC rate and SH prices were considerably low until 1996. In monthly sample data, over the period of 1996-2017, the correlation between SQ and the other two variables significantly increased. The low correlation between SQ-TC and SQ-SH showed that the calculated nominal SH tanker prices stayed far above the market price, and the TC rate did not follow the increasing trend as the SQ indicator had signaled. Although the SQ indicator signaled for sell, where the price increased as expected, the SH price and TC rate did not increase. This was due to the Gulf Crisis, which resulted in an extreme increase in oil prices. According to M. G. Kavussanos (1996), oil prices are negatively linked to changes in tanker prices and positively linked to the volatilities in the freight market, which explains the disparity between the SQ indicator and the other two indicators until 1996. They moved in the opposite direction due to the impact of the Gulf Crisis.

Table 4.6 Correlation Matrix of Tanker TC Rate, SH Prices, and SQ (1996-2017)

Product$_{5}$		β_{5}	Φ_{sq}	∞	Product$_{10}$	β_{10}	Φ_{sq}	∞	Product$_{15}$	β_{15}	Φ_{sq}	∞
SH$_{5}$	β_{5}	1.0000			β_{10}	1.0000			β_{15}	1.0000		
SQ	Φ_{sq}	0.7375 (0.0000)	1.0000		Φ_{sq}	0.7879 (0.0000)	1.0000		Φ_{sq}	0.9035 (0.0000)	1.0000	
TC	∞	0.8840 (0.0000)	0.8006 (0.0000)	1.0000	∞	0.8552 (0.0000)	0.7696 (0.0000)	1.0000	∞	0.8901 (0.0000)	0.8740 (0.0000)	1.0000
Aframax$_{5}$		β_{5}	Φ_{sq}	∞	Aframax$_{10}$	β_{10}	Φ_{sq}	∞	Aframax$_{15}$	β_{15}	Φ_{sq}	∞
SH$_{5}$	β_{5}	1.0000			β_{10}	1.0000			β_{15}	1.0000		
SQ	Φ_{sq}	0.7071 (0.0000)	1.0000		Φ_{sq}	0.7833 (0.0000)	1.0000		Φ_{sq}	0.8793 (0.0000)	1.0000	
TC	∞	0.8915 (0.0000)	0.8279 (0.0000)	1.0000	∞	0.8619 (0.0000)	0.7481 (0.0000)	1.0000	∞	0.8226 (0.0000)	0.8573 (0.0000)	1.0000
Suezmax$_{5}$		β_{5}	Φ_{sq}	∞	Suezmax$_{10}$	β_{10}	Φ_{sq}	∞	Suezmax$_{15}$	β_{15}	Φ_{sq}	∞
SH$_{5}$	β_{5}	1.0000			β_{10}	1.0000			β_{15}	1.0000		
SQ	Φ_{sq}	0.6622 (0.0000)	1.0000		Φ_{sq}	0.7861 (0.0000)	1.0000		Φ_{sq}	0.9429 (0.0000)	1.0000	

TC	∞	0.8266 (0.0000)	0.8194 (0.0000)	1.0000	∞	0.7543 (0.0000)	0.7521 (0.0000)	1.0000	∞	0.8011 (0.0000)	0.8722 (0.0000)	1.0000
$VLCC_5$		β_5	Φ_{sq}	∞	$VLCC_{10}$	β_{10}	Φ_{sq}	∞	$VLCC_{15}$	β_{15}	Φ_{sq}	∞
SH_5	β_5	1.0000			β_{10}	1.0000			β_{15}	1.0000		
SQ	Φ_{sq}	0.6184 (0.0000)	1.0000		Φ_{sq}	0.7451 (0.0000)	1.0000		Φ_{sq}	0.8961 (0.0000)	1.0000	
TC	∞	0.8608 (0.0000)	0.7231 (0.0000)	1.0000	∞	0.8257 (0.0000)	0.7576 (0.0000)	1.0000	∞	0.7105 (0.0000)	0.6916 (0.0000)	1.0000

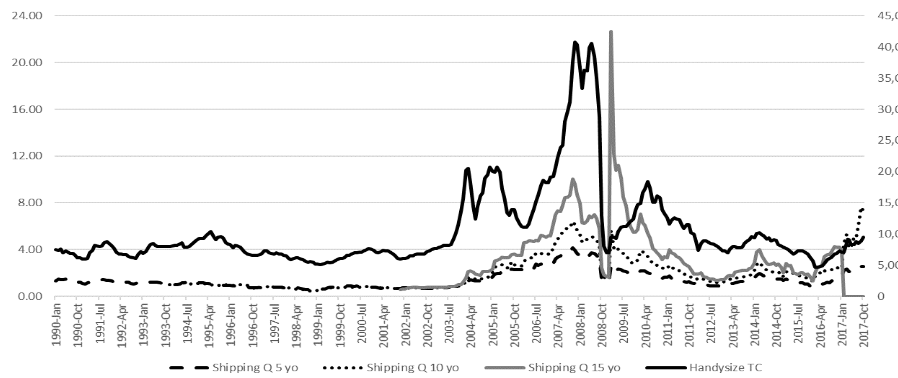
Source: Author (SQ indicator), Clarkson (TC rate & SH prices)

P-values are given in the parenthesis

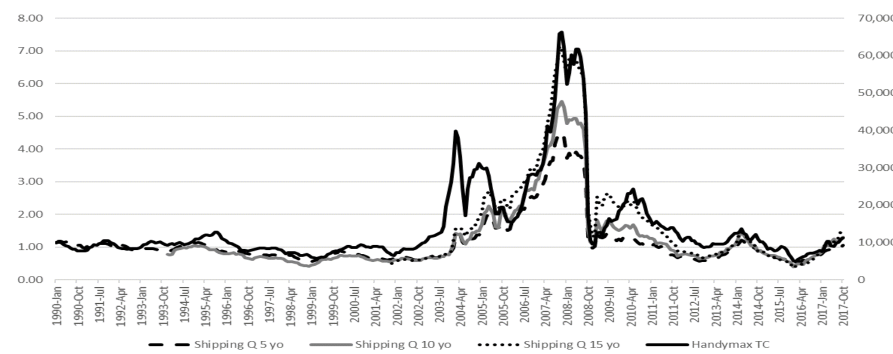
4.4.2 Shipping Q Analysis for Dry Bulkers

Figure 4.21 demonstrated the monthly SQ indicator results for dry bulkers: Handysize, Handymax, Panamax, and Capesize. Monthly SQ indicators were presented with the TC rates to refer to the changes in TC rates. The short-term volatilities were observed compared to the results of the yearly SQ, where the short-term volatilities were smoothed out. The responses of the SQ indicator during the crisis period 2003-2008 are sharper than yearly SQ indicator results. This is due to the data being discounted monthly. In general, yearly SQ results are beneficial to observe the general trend in the market, whereas monthly SQ results are useful to consider monthly sensitive evaluation.

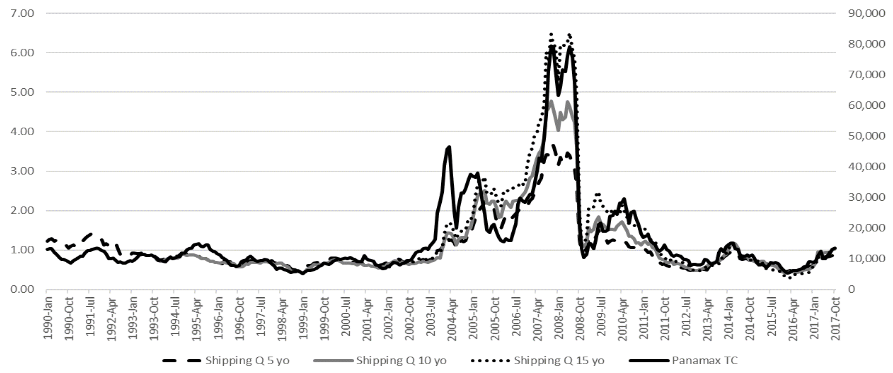
(a)



(b)



(c)



(d)

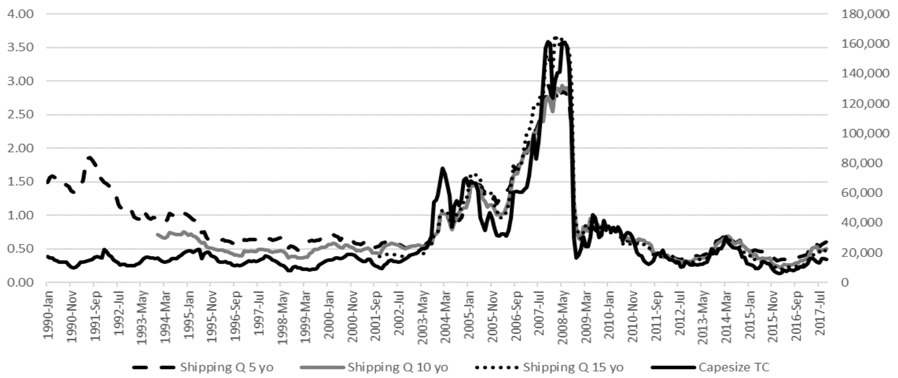


Figure 4.21. Calculated SQ Ratio for Bulker Carrier and Bulker TC Rate *(SQ ratio is on the left scale while time charter rate on the right scale)*. **(a)Handysize, (b) Handymax, (c) Panamax, (d) Capesize**

Source: Author (SQ indicator), Clarkson (TC rate)

Similar to the yearly SQ results, the results of the monthly SQ for dry bulk carriers in Figure 4.21 attracted attention before and after the 2008 GFC when extreme ups and downs were witnessed in the market. To reflect the impact of the 2008 GFC, the sample is divided into three sub-samples: 1990-2003; 2003- 2008 and after the 2008 GFC. From 1990 to 2003, SQ moved around the level of 0.80 to 2.00 for Handysize, Handymax, and Panamax; Capesize SQ started from around 1.60 and gradually decreased. Between 2003 and 2008, the historical peak level was witnessed in the shipping markets. Notably, the SQ indicator indicated an extremely high level for 5-year-old Handysize ships. After the

2008 GFC, all SQ indicators had gone below 1.00 level, indicating a strong buy signal until 2017.

Referring to Figure 4.21 (a), the Handysize SQ short-term volatility for different age vessels were captured along with TC rate changes. Notably, the volatility captured by the monthly SQ indicator between 2003 and 2004 specified the opportunity to exit from the market, which has been smoothed out in the yearly SQ results.

The cross-correlation analysis for Handysize was conducted on a monthly basis in Figure 4.22, and the figure provided short-term time-lag information in detail.

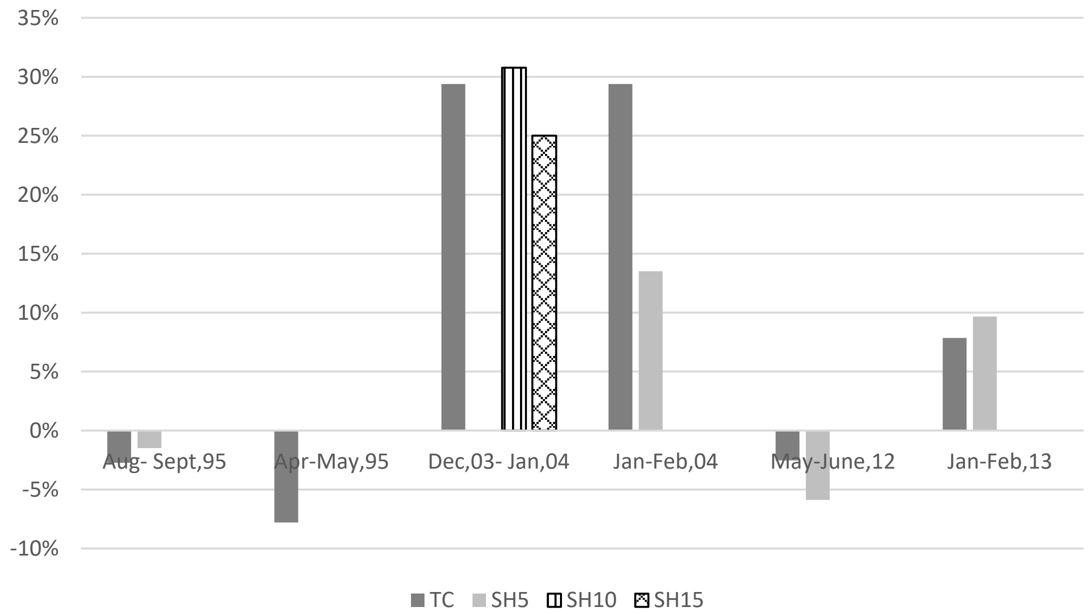


Figure 4.22. TC Rate and Handysize SH Prices Change after SQ Indicator Below/Above Level 1.00

Source: Clarkson

The cross-correlation[16] results of SQ_5 and SH prices indicated the time lag was from one month to two months, which stated that when the Handysize SQ increased/ decreased for the given period, the SH prices were most likely to increase/ decrease. The cross-correlation between SQ_5 and TC indicated that the time lag varied from zero to one month. That is, the change in SQ_5 is followed by TC rates within a month. Considering that the SQ_5 indicator gave a sell signal when it exceeded level 1.00, the signal can be translated into that the TC rate and SH prices were expected to drop after the determined period. As shown in Figure 4.22, in January 1990, SQ_5 Handysize was 1.336, while in February 1990, TC rates decreased by 2%, and in March, SH prices had dropped by 3%. In February 2004, SQ_5 Handysize was 1.1877, while in April 2004, TC rates lost value by 11%, and in May 2004, SH prices decreased by 9%.

Moreover, the cross-correlation between the SQ_{10} indicator and SH prices indicated that the time lag varied from two to three months. The movement of SQ_{10} was followed by SH prices within two to three months. The cross-correlation between SQ_{10} and TC rate results indicated that the time lag varied between zero and two months. Where SQ_{10} signals exceeded level 1.00, in the following three months, SH price was expected to drop, and in the following two months, the TC rate was expected to drop. As shown in Figure 4.22, TC rate and SH prices had dropped by 11% and 9%, respectively, in May 2004, after SQ_{10} went above level 1.00 in December 2003.

The cross-correlation between the SQ_{15} indicator and SH prices indicated the time lag was one month. As shown in Figure 4.22, in December 2003, SQ_{15} went above level 1.00, and in the following month, SH price and TC rate increased by 25% and 29%,

[16] Cross correlation results are provided in the Appendix 1B.

respectively. The SQ_{15} indicator stayed above level 1.00 for the rest of the analyzed period.

Referring to Figure 4.21 (b), monthly Handymax SQ indicators, and TC rates are plotted. As observed in the Handysize monthly and yearly SQ indicators, the same applied to the Handymax results. Short term volatilities were clearly observed in the monthly analysis comparing to the yearly analysis, which allowed market participants to make the entry and exit decisions in the short-run. The monthly cross-correlation results are provided in Figure 4.23.

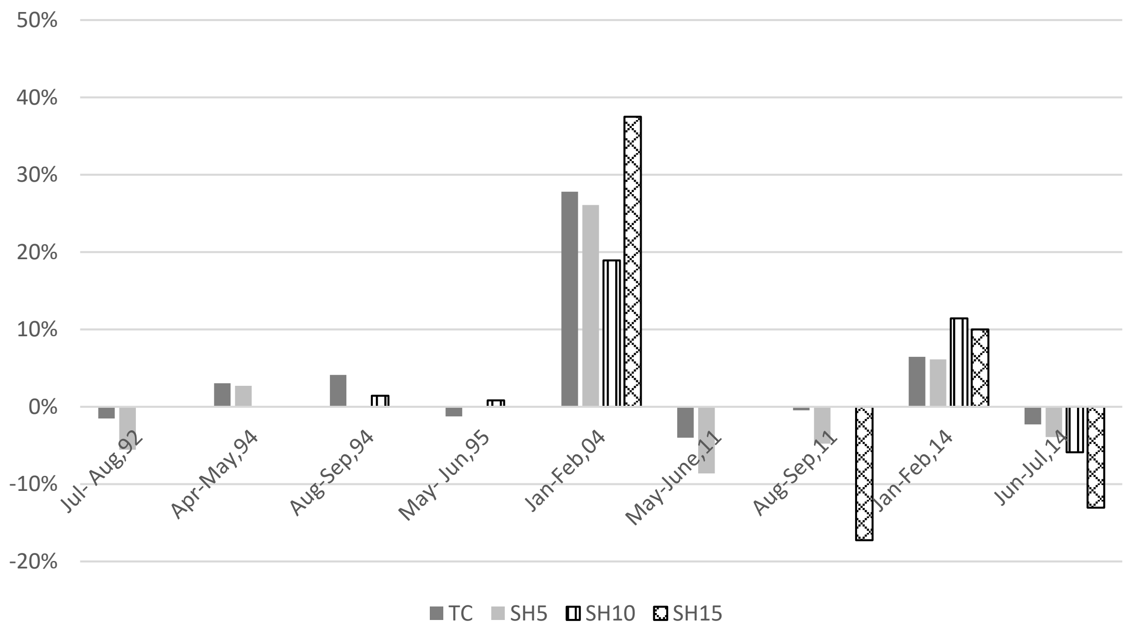


Figure 4.23. TC Rate and Handymax SH Prices Change after SQ Indicator Below/Above Level 1.00

Source: Clarkson

The cross-correlation analysis for the TC rate and SQ_5 indicated the time lag was less than a month. For the given sample, it is expected that when SQ starts increasing, the TC rate is supposed to start decreasing within a month. As shown in Figure 4.23, in January 1990, when SQ_5 exceeded level 1.00, it was monitored that the TC rate started decreasing in a month. The decrease continued until the SQ was below level 1.00. However, in February 2011, although SQ_5 exceeded level 1.00, TC rate did not show a decreasing trend throughout the year. The same inconsistencies applied to 1992 and 1994, while SQ_5 and TC rate moved oppositely in 1992 and 1994, while SQ exceeded level 1.00, the TC rate continued to increase. This leads to further analysis regarding the SQ optimization level since equilibrium level 1.00 did not help to produce a general assumption about the movement of TC rate and SQ indicator. The cross-correlation between the SQ_5 indicator and SH price indicated that time lag varied between one and two months. As given in Figure 4.23, in March 1990, the SQ indicator was 1.1762, and the SH price had dropped by 3% in April 1990.

The cross-correlation analysis for the TC rate and SQ_{10} indicator showed that the time lag was from zero to one month. When the SQ_{10} indicator exceeded level 1.00, the TC rate mostly did not show considerable change, and it mostly increased or decreased by 1%. As shown in Figure 4.23, the only exception was the February 2004 period, where the SQ indicator was 1.413, and the TC rate had dropped by 4% in March 2004. The cross-correlation analysis for the SH price and SQ_{10} indicator showed that the time lag was from zero to two months. In February 2004, when the SQ indicator was 1.4136, the SH price had dropped by 2% in April 2004.

The cross-correlation analysis for the TC rate and SQ_{15} indicator showed that the time lag was from zero to one month, where the SQ_{15} indicator exceeds level 1.00, which is after January 2004, the TC rate decreased after a month. As shown in Figure 4.23, in February 2004, the SQ indicator was 1.5675, and the TC rate had dropped by 4% in March 2004. The cross-correlation analysis for the SH price and SQ indicator shows that the time lag was from zero to two months. In February 2004, while the SQ indicator was 1.5675, SH price had dropped by 6% in May 2004.

Referring to Figure 4.21 (c), monthly Panamax SQ_5 and TC rate were plotted. The volatilities during the GFC period, 2003-2005 and 2005-2008, were observed. The monthly SQ strongly signaled for sell, whereas the yearly SQ indicator did not give sell signals for the same time period. The cross-correlation analysis of the monthly SQ indicator, TC rate, and the SH prices are reported in Figure 4.24.

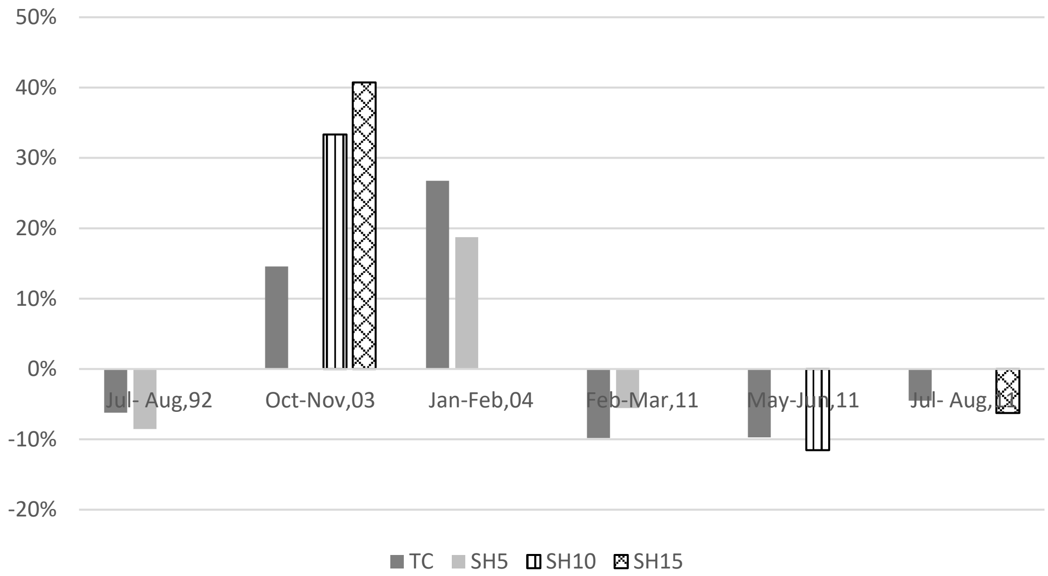


Figure 4.24. TC Rate and Panamax SH Prices Change after SQ Indicator Below/Above Level 1.00

Source: Clarkson

The cross-correlation analysis for the TC rate and SQ_5 indicator demonstrated that the time lag was from zero to two months. The movement of SQ, TC, and SH are reported in Figure 4.24, with the time lag taken into consideration. When the SQ indicator exceeded level 1.00, the TC rate decreased within one to two months. For example, in January

1990, the SQ indicator was 1.2207, and the TC rate had dropped by 9% in April 1990. Within the same period, SH price had dropped by 7%. The cross-correlation analysis for the SH price and SQ indicator indicated that the time lag was from zero to two months.

The cross-correlation analysis for the TC rate and SQ_{10} indicator indicated the time lag is from one to two months. When the SQ indicator exceeded level 1.00, the change in TC rate varied between two months and five months. As shown in Figure 4.24, in November 2003, the SQ indicator was 1.0412, and the TC rate had dropped by 20% in April 2004. Within the same period, SH price dropped by 2%. The cross-correlation analysis for the SH price and SQ indicator showed that the time lag was from one to three months.

The cross-correlation analysis for the TC rate and SQ_{15} indicator showed the time lag was from zero to one month. When the SQ_{15} indicator exceeded level 1.00, the change in TC rate varied between two months and five months. As given in Figure 4.24, in December 2003, the SQ_{15} indicator was 1.0443, and the TC rate had dropped by 20% in April 2004. Within the same period, SH price had dropped by 2%. The cross-correlation analysis for the SH price and SQ_{15} indicator indicated that the time lag was from zero to one month.

Referring to Figure 4.21 (d), the monthly Capesize SQ indicator and TC rate were plotted. Monthly results provided a better short-term output of the SQ indicator along with TC rate moves. The cross-correlation results are provided in Figure 4.25 to evaluate the corresponding change of TC rate and SH prices following SQ indicator signals.

The cross-correlation between the SQ_5 indicator and the two variables, SH prices, and TC rate, indicated zero to one-month time lag. The SQ_5 indicator changes, TC rate, and SH prices change within a month. The described positive cross-correlation was monitored throughout the sample period after February 2004.

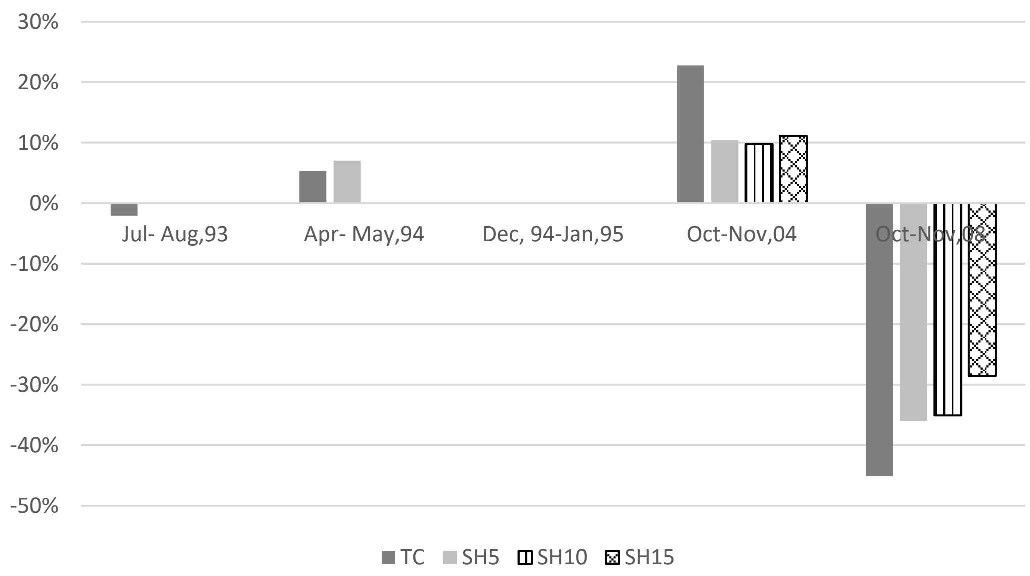


Figure 4.25. TC Rate and Capesize SH Prices Change after SQ Indicator Below/Above Level 1.00

Source: Clarkson

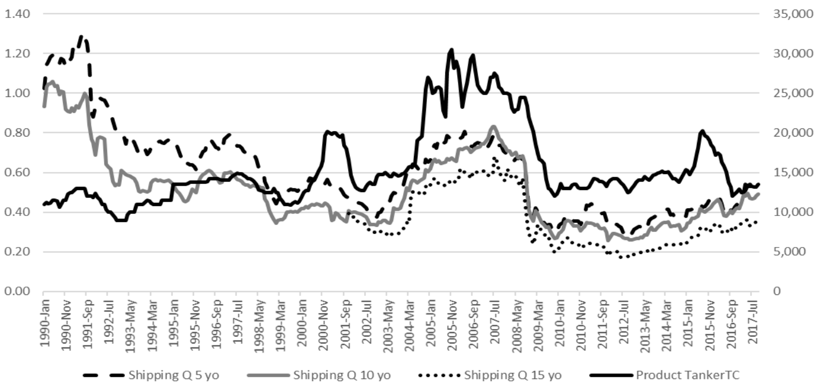
As shown in Figure 4.25, changes in the SQ_5 indicator were followed by TC rate and SH price changes. Before the GFC period, a slight decrease and increase were captured in SH prices and TC rates after SQ_5 changes. In October 2004, SH prices and TC rates increased by 10% and 23% respectively, while in October 2008, after the GFC, SH prices and TC rate significantly had dropped by 36% and 45%, respectively.

The cross-correlation between the SQ_{10} indicator and the two variables, SH prices, and TC rate, indicated a zero to the two-month time lag, while the SQ_{15} indicator and the two variables, SH prices and TC rate, indicated a zero to one-month time lag. The SQ_{10} and SQ_{15} were not active as SQ_5; they did not exceed level 1.00, except for the time during the crisis period. The impact of the 2008 GFC clearly monitored from October-November 2008 period, as shown in Figure 4.25.

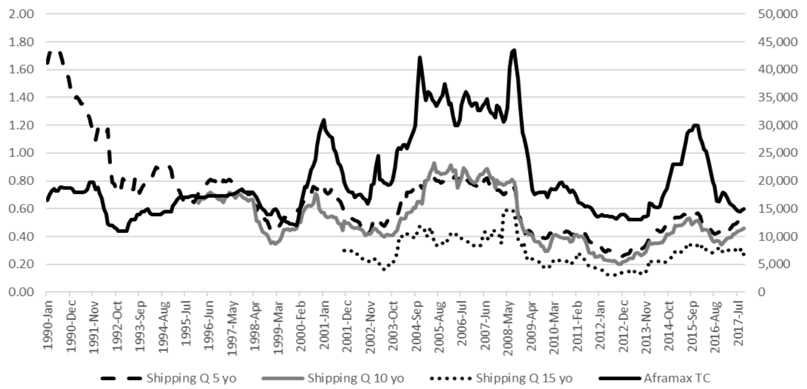
4.4.3 Shipping Q Analysis for Tankers

Figure 4.26 demonstrates monthly SQ results for tankers: Product Tanker, Aframax, Suezmax, and VLCC. The monthly SQ is presented with TC rates to compare the movement of the SQ indicator and TC rates in the long run. In contrast to yearly SQ tanker results, monthly SQ shows a highly volatile trend in a short-term period as expected.

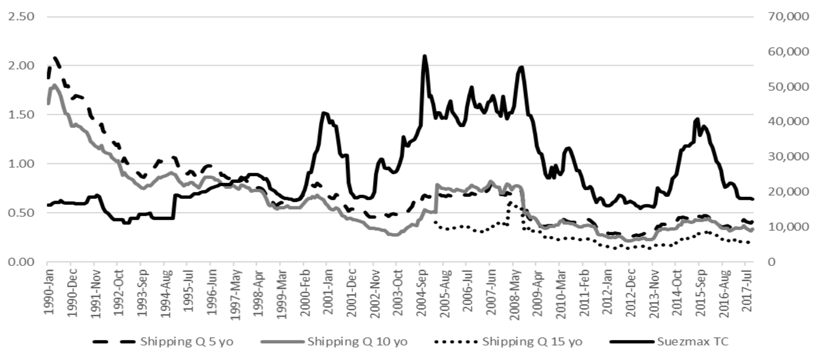
(a)



(b)



(c)



(d)

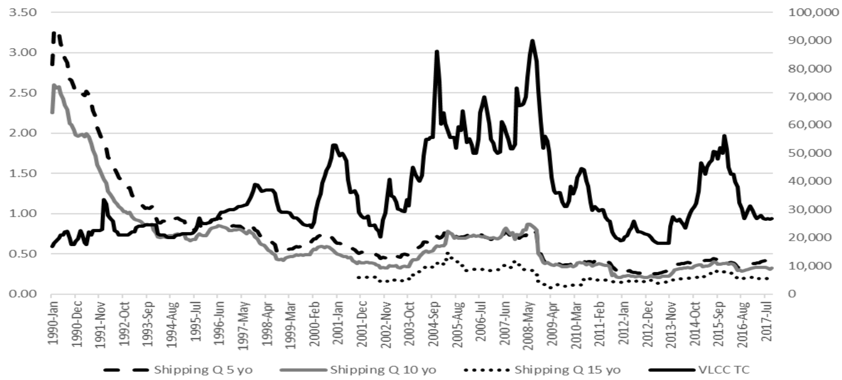


Figure 4.26 Calculated SQ ratio for Tanker Carrier and Tanker TC Rate *(SQ ratio is on the left scale while time charter rate on the right scale)* **(a)Product Tanker, (b) Aframax, (c) Suezmax, (d) VLCC**

Source: Author (SQ indicator), Clarkson (TC rate)

In monthly SQ tanker analysis, the cross-correlation is discussed for each vessel type. During the period from 1990 till 1997, SQ indicator signals were not significantly followed by TC rate and SH prices due to the oil crisis shock in the market, which lead to unexpected oil price increases (UNCTAD, 1995). By focusing on the period after 1997, the cross-correlation analysis produced a robust and meaningful outcome.

The cross-correlation results showed that the time lags between the SQ_5 and SH prices-TC rates were four months. The SQ_5[17] signals followed by SH prices and TC rate changes, as shown in Figure 4.27. The time lag between SQ_{10} and SH price, TC rates were two to three months. The SQ_{15} indicator and SH prices had a one to two months time lag, while the SQ_{15} indicator and TC prices time lag was two to three months. The responsiveness of TC rate and SH prices to SQ indicator change were less sensitive until 1997. Although 10-year-old SH prices responded to the changes in SQ_{10}, 5-year-old and 15-year-old SH were not responsive until 1997.

[17] Since SQ indicator rarely exceeds level 1.00 in Product Tanker, the level 0.70 is considered as a sell signal level.

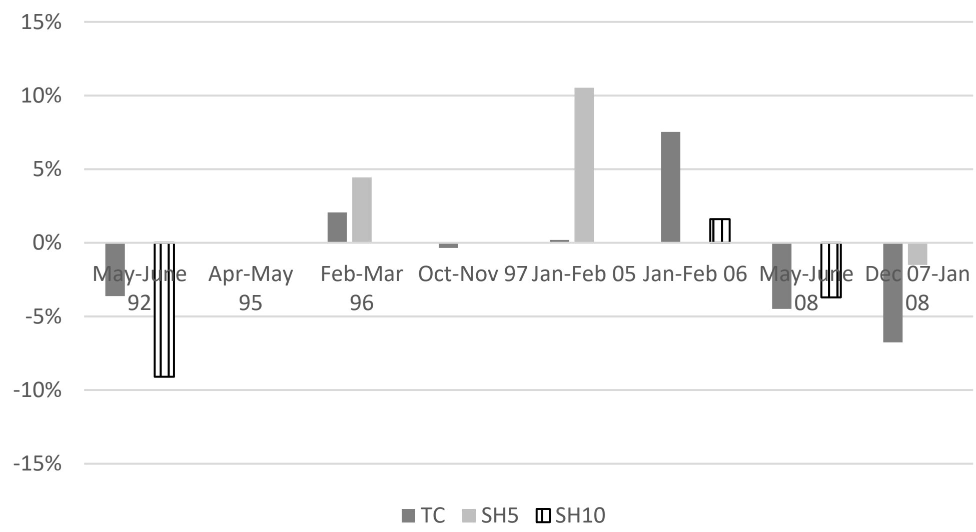


Figure 4.27. TC Rate and Product Tanker SH Prices Change after SQ Indicator Below/Above Level 1.00
Source: Clarkson

The correlation between SQ and TC rate-SH prices were weak from 1990 to1996. By restricting our attention to the period after 1998, the cross-correlation results could produce a robust outcome. The results indicated that the time lag between SQ and SH prices was from two to three months. For example, in February 2005, SQ indicator was 0.82[18], while in April 2005, SH price was decreased by 1%, and by 3% in May 2005. The cross-correlation between the SQ indicator and TC prices indicates that this time lag was two to three months.

As shown in Figure 4.28, the SQ indicator changes were generally followed by SH price and TC rate changes. The cross-correlation analysis results showed that the time lag between SQ_{10} and SH prices was from one to two months, but it varied from three to four months in the sample.

[18] Since SQ indicator never exceeds level 1.00 in $Aframax_5$, the highest level is considered as a sell signal level.

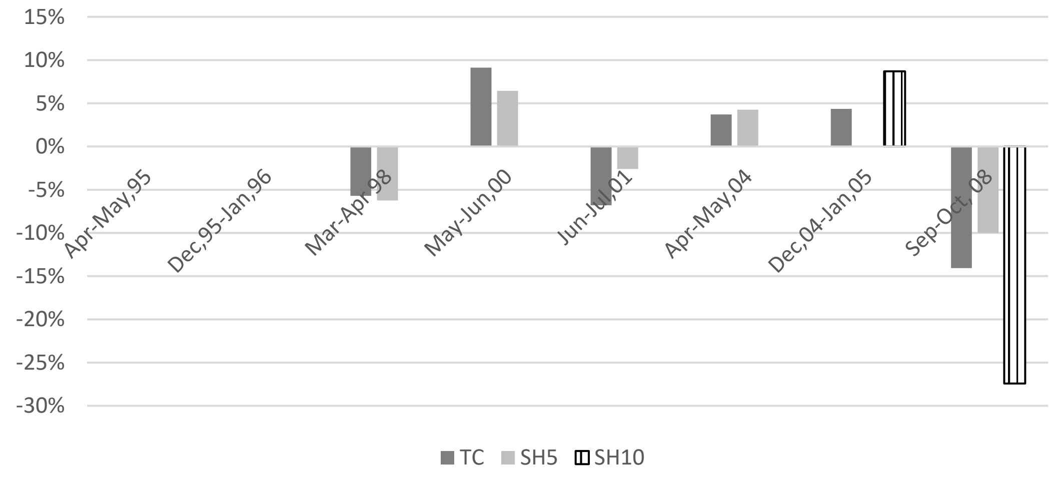


Figure 4.28. TC Rate and Aframax SH Prices Change after SQ Indicator Below/Above Level 1.00

Source: Clarkson

For example, in March 2005, the SQ indicator was 0.81[19], while in July 2005, SH price was decreased by 7%. The cross-correlation between the SQ indicator and TC prices indicates the time lag was two to three months. Over the same period, from March 2005, the TC rate had dropped by 3% in May 2005.

Also, the cross-correlation analysis results showed that the time lag between SQ_{15} and SH prices were less than a month. For example, in August 2008, the SQ indicator was 0.57, while in September 2008, SH price had decreased by 9%. The cross-correlation between the SQ indicator and TC prices indicates the time lag was one month. Over the same period, from August 2008, the TC rate dropped by 5% in September 2008.

The cross-correlation of Suezmax was also analyzed, and the price changes were reported in Figure 4.29. The time lag between SQ_5 and SH prices was from one to two months.

[19] Since SQ indicator never exceeds level 1.00 in Aframax, the highest level is considered as a sell signal level.

For example, in February 2005, the SQ indicator was 0.71[20], while in March 2005, SH price did not change. The cross-correlation between the SQ_5 indicator and TC prices indicated the time lag was two to three months. Over the same period, from February 2005, the TC rate had increased by 9% in April 2005.

The results showed that the time lag between SQ_{10} and SH prices was one month. For example, in May 2005, the SQ indicator was 0.79, while in July 2005, SH dropped by 3%. The cross-correlation between the SQ indicator and TC prices indicates that this time lag was a month. Over the same period, from May 2005 to July 2005, the TC rate had decreased by 4%. The cross-correlation analysis results show that the time lag between SQ and SH prices were less than a month. For example, in August 2008, the SQ indicator was 0.56, while in September 2008, SH price was decreased by 3%. The cross-correlation between the SQ indicator and TC prices indicates the time lag was one month. Over the same period, from August 2008, the TC rate had dropped by 8% in October 2008.

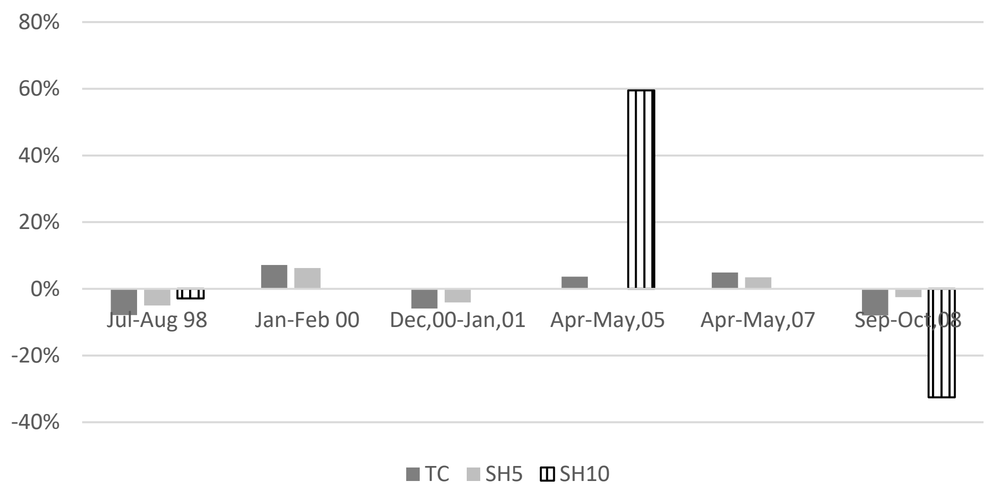


Figure 4.29. TC Rate and Suezmax SH Prices Change after SQ Indicator Below/Above Level 1.00

Source: Clarkson

[20] Since SQ indicator never exceeds level 1.00 in Suezmax, the highest level is considered as a sell signal level.

The cross-correlation analysis was held for VLCC, and the price changes were presented in Figure 4.30. The results showed that the time lag between SQ_5 and SH prices was two months. For example, in March 2005, the SQ_5 indicator was 0.79[21], while in May 2005, SH price did not change. The cross-correlation between the SQ indicator and TC prices indicates the time lag was two to three months. Over the same period, from March 2005 to May 2005, the TC rate had decreased by 4%. The results show that the time lag between SQ_{10} and SH prices was from zero to one month. For example, in June 2007, the SQ indicator was 0.80[22], while in August 2007, SH price had dropped by 3%. The cross-correlation between the SQ indicator and TC prices demonstrated that the time lag was one month. Over the same period, from March 2005, the TC rate had decreased by 4% in August 2007.

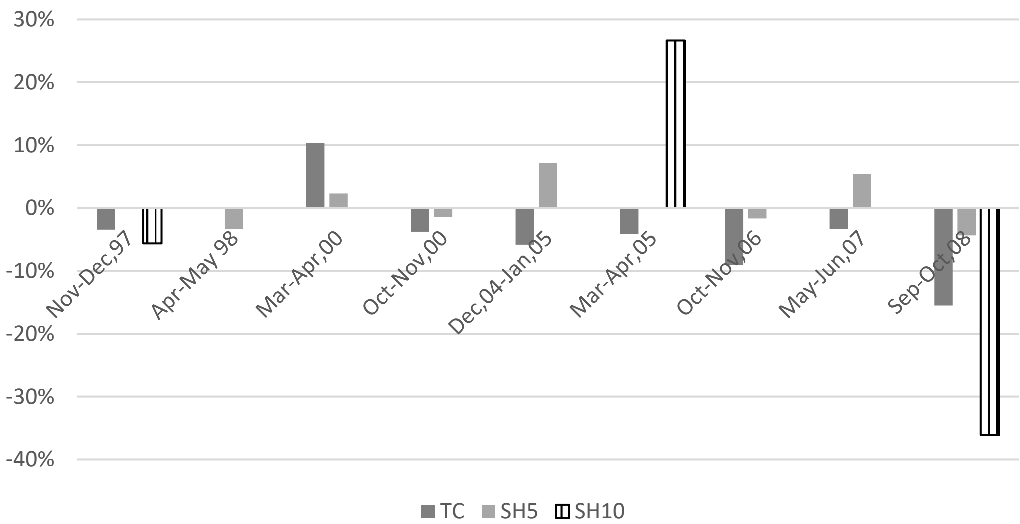


Figure 4.30. TC Rate and VLCC SH Prices Change after SQ Indicator Below/Above Level 1.00

Source: Clarkson

[21] Since SQ indicator never exceeds level 1.00 in $VLCC_5$, the highest level is considered as a sell signal level.
[22] Since SQ indicator never exceeds level 1.00 in $VLCC_{10}$, the highest level is considered as a sell signal level.

Lastly, the cross-correlation analysis results showed that the time lag between SQ_{15} and SH prices were less than a month. For example, in December 2004, SQ indicator was 0.41[23], in February 2005, SH price was decreased by 10%. The cross-correlation between the SQ_{15} indicator and TC prices showed the time lag is two months. Over the same period, from December 2004, the TC rate had dropped by 6% in March 2005.

4.5 Sensitivity Analysis

The economic life of a ship and the average TC rate is back-tested to demonstrate their sensitivity in SQ calculation. The economic life of a ship varies between 15 years and 30 years (Alizadeh et al., 2010; Stopford, 2009). In order to clear the ambiguity in SQ calculation, SQ is calculated for the 20 and 25 years old economic life of a ship separately. The result is provided in Section 4.5.1. Also, in SQ calculation, the 10-year average of the TC rate is used to estimate future cash flow (operating income). To show the impact of different TC rate averages on the SQ indicator, 10-, 15- and 20-year averages are used. The result is presented in Section 4.5.2.

4.5.1 Sensitivity Analysis of the Economic Life of a Ship

Generally, it is accepted that ships have an economic life of 15–30 years (Stopford, 2009). In this research, 25 years of economic life for each vessel is considered, which is based on the average demolition age of tankers and dry bulk carriers shown in Figure 4.31. To evaluate the effect of the assumption of the length of the economic life of the ship, 5-year-old Capesize SQ is tested. The result is illustrated in Figure 4.29, where the difference between SQ_{20} and SQ_{25} ratio was less than 0.10, except the peak level

[23] Since SQ indicator never exceeds level 1.00 in $VLCC_{15}$, the highest level is considered as a sell signal level.

experienced in the TC rate from 2005 to 2008, which reached 0.50. On the other hand, to avoid the short term volatilities sourced by the economic life of a ship, either 20 years or 25 years were used, and the less volatile result was chosen. As illustrated in Figure 4.29, 20 years of the economic life of a ship plot less volatile SQ results. Therefore, the economic life of a ship in the calculation of the SQ indicator was taken as 20 years.

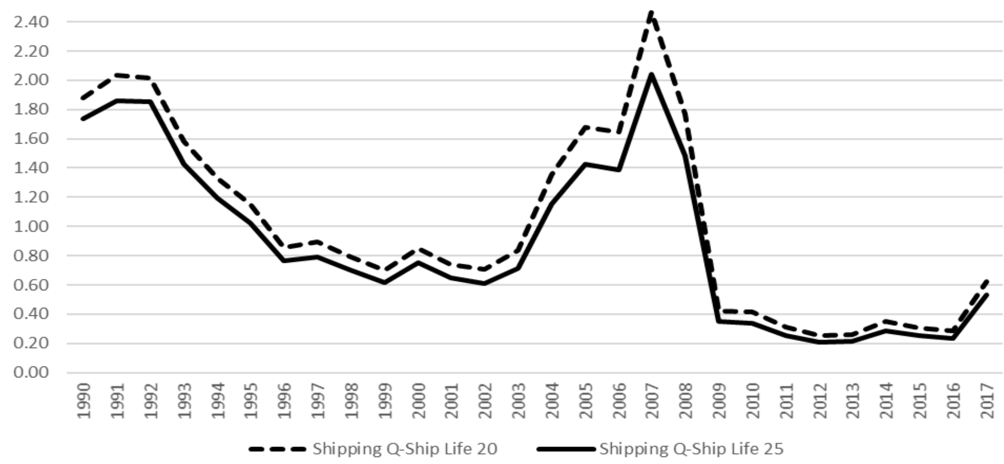


Figure 4.31 Sensitivity Analysis of The Economic Life of a Ship

Sources: Author

4.5.2 Sensitivity Analysis of Time Charter Rate in SQ Calculation

Sensitivity analysis is run for SQ calculation to measure the effect of using 10-, 15-, and 20[24] -years average of the TC rate. The results show that there is no significant impact of using different period averages. This is due to the fact that long term averages smooth out the impact of short term volatilities (Michael, 2015). For the Capesize bulker, the difference between using 10, 15- and 20- year average of TC rate varies between 0.17

[24] 20 years average was partially applied since available data for a 1-year time charter rate goes back to 1976.

and -0.20 level. In Figure 4.32, the sensitivity analysis of Capesize 5-year-old, 10-,15- and 20-years average of the TC rate applied to SQ calculation. As the difference between the TC rate averages does not show significant gaps, a 10-year average of one-year TC rate is used to calculate the future cash flow of each vessel.

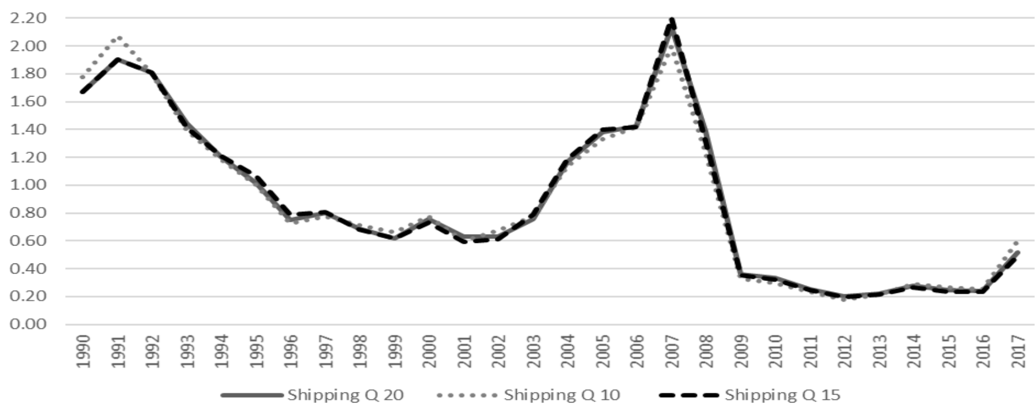


Figure 4.32 Sensitivity Analysis of Time Charter Rate in Shipping Q Calculation of Capesize Bulker

Sources: Author

4.6 Summary

This chapter provided an indicator, SQ, which is the adaptation of the Tobin Q indicator. The SQ indicator was developed for the dry bulk and tanker markets, and the yearly and monthly SQ results were presented in Chapter 4. In Section 4.2, the indicator was introduced, and its working mechanism was explained. The SQ indicator mainly revealed the discrepancy between market prices and the long-term nominal value of a ship and reflected any mispricing or market bubble. This, in turn, sheds light on ship investment timing and market entry-exit decision. In Sections 4.3 and 4.4, the yearly and monthly SQ results were provided. The signals of SQ was interpreted for the dry bulk and tanker markets. In Section 4.5, the sensitivity analysis was conducted for the economic life of a ship and the TC rate averages.

Chapter 5 Optimization of Shipping Q

5.1 Introduction

In this chapter, SQ has been optimized subject to annual investment return. Section 5.2 introduces the optimization of monthly SQ. The theoretical background and process of optimization are introduced. Section 5.3 provides the upper and lower bands of SQ to be optimized in a given data set. Then the pseudo-predictive performance of optimized SQ is tested in a holdout set, and results are provided. Lastly, Section 5.4 summarizes Chapter 5.

5.2 Optimization of SQ Index

Investment timing and investment return performance have been researched by using various methods, buy and hold (Ådland et al., 2004; N. C. Papapostolou et al., 2014) and relative strength index (Arevalo et al., 2018) strategies. Necessarily, buy and hold benchmark strategy had been applied to the second-hand market. Ådland et al. (2004); Adland et al. (2006) studied and compared the buy-hold strategies with various approaches, such as moving average and technical trading rules. They found that the buy-hold benchmark performs better than trading rules in the second-hand dry bulk market. Using the buy - hold strategy, the investor buys the ship on backdated time, for example, January 1, 1990, and operates the vessel in the spot market to the present day. Monthly profit is calculated by the time charter rate minus the monthly operating cost of the vessel.

Similarly, the SQ indicator was calculated using the same approach. However, the optimization process was managed by the buy and sell mechanism. To obtain the optimized level of the SQ indicator, different upper and lower bands were tested to find out the best combination to invest and gain maximum return for the given data set. In the optimization of the SQ, the value maximization theory has been used.

Monthly SQ was optimized to identify the optimal upper and lower bands of buy and sell signals for each type of vessel. The contemporary interpretation of the Tobin Q theory stated that the buy and sell signals need to be set below level 1.00 and above level 1.00, respectively (Mihaljevic, 2010). This could be interpreted that if the market value of an asset is over book value of an asset, then there is overvaluation and investment need to be delayed, or divestment/ sell action may start. The level 1.00 approach could also be applied to the shipping industry, considering its high price volatilities and persistent overvaluation and undervaluation problems (Stopford, 2009). However, the SQ tanker indicator rarely exceeded level 1.00 during the 2008 GFC, indicating that tanker vessels never signaled for a sell. It consistently gave a buy signal, which was not realistic. In order to identify the realistic level of optimization for both dry bulker and tanker, the upper and lower bands are identified by applying the value maximization approach.

The equation (3.7) is applied to the SQ indicator as below equation (5.1):

$$E\left(R\left(S\left(I_{opt}\right)\right)\right) = \max_{I \in B/S} E\left(R\left(S(I)\right)\right), \qquad (5.1)$$

Where rational investor maximizes the investment return $R\left(S(I)\right)$ by optimizing the investment options I_{opt} € B/S for the second-hand ship investments $S(I)$.

The optimization is organized and applied separately for each vessel type for dry bulker and tanker from 1995 to 2015. It is assumed that the same initial capital was applied, US$100 million[25], seeking to buy a 5-year-old vessel. Operational income was calculated as revenues (time charter rate multiplied by 350) minus operating expenses (daily operating expenses multiplied by 365). After the first sell signal, a three-month time-lapse was counted, and the ship was sold at the corresponding second-hand price. Sell income was added to the cash flow. A three-month waiting period was assumed to be the time gap between the decision and the ship purchase, cash outflows were shown, and operational income was estimated as a cash inflow throughout the period the ship operates until the first sell signal. The sale and buy process of a ship might vary between a few weeks to several months (Alizadeh et al., 2010). The process includes five stages, placing the ship to the market, negotiation of the price and the conditions, memorandum of agreement, inspections, and finally delivering the ship to the new owner (Stopford, 2009). Considering these stages, three months of buy/sell transaction gap was taken into consideration.

The optimization of the SQ indicator was tested subject to maximum return level. The ship was bought when the buy signal was given by the SQ indicator, and operational income was calculated during the ship was operated until the sell signal received. The income by the sale of the ship was added to the cash flow. Eventually, the sell and buy operations were conducted from 1995 till 2015, and the ship was sold by the end of the test period unless sold before.

The upper and lower levels of optimization were identified through the trial and error method. For the bulker carrier, the optimization process started to test from level 1.00 to

[25] The amount is set as a fixed amount applied to all scenarios.

0.50 for a buy signal, level 0.80 to 1.40 for a sell signal. For the tanker carrier, it started to test from level 0.40 to 0.70 for a buy signal, level 0.70 to 0.90 for a sell signal. The intervals were tested for tenths and hundreds; only significant results were reported in Section 5.3.

The process of investment return maximization, as illustrated below:

Step 1: Identify the upper and lower bands to test[26]

Step 2: Calculate expected cash flows and operating expenses from 1995 to 2015

Step 3: Wait until the first buy signal

Step 4: After the first buy signal, buy ships after three months period, considering the decision-making time gap (Cash outflows)

Step 5: Proceed with net income (total revenues minus operating expenses) until the first sell signal (Cash inflows)

Step 6: After the first sell signal, sell the ship after three months period at the corresponding second-hand ship price (Cash inflows)

The buy and sell operations continue until the end of a sample period

Step 7: At the end of the sample period 2015, if ships are still operating, they are sold at the corresponding second-hand ship price (Cash inflows)

The identified steps were applied to dry bulker and tanker carriers for the given sample period from 1995 to 2015. The SQ signals were interpreted for only 5-year-old vessels, the economic life of a ship was therefore accepted as 20-year. SQ_{10} and SQ_{15} were excluded from the optimization analysis.

[26] While identifying upper and lower level of optimization for each tonnage, smallest decimal changes are also tested, but the outcome is not reported since there was no significant difference.

5.3 Optimization Results

In the ship asset management, market entry and exit decisions have significant importance to determine investment return level. Being extraordinarily patient or impatient with the expectation of high/low second-hand ship prices or time charter rates might have a crucial impact on the ship asset management process (Bulut et al., 2013). There are various reasons behind being patient or impatient, which can be explained by the irrationality of the decision-making process (Duru, 2016), herd behaviour (N. Papapostolou et al., 2017), and liquidity concerns (Bulut et al., 2013). Turning to the shipping industry, the optimization process of the SQ indicator sheds light on rule-based asset management and provides a technical approach to interpret market signals with the mean-reversion approach.

The SQ indicator as a market guiding indicator could provide some certain benefits to market participants in terms of anticipating the future direction of the market. The calculated value of a ship in the SQ indicator was an estimated natural price of a ship, which was found by estimating future cash flows assuming a mean-reverting second-hand ship market. That is, it was assumed that the market price tends to move to the average price over time (Hillebrand, 2003). The mean-variance strategy was also found statistically significant for various sample data, including asset portfolio (Caporin et al., 2012). Following the mean-reversion assumption, the long-term value of a ship could be calculated. The optimization results of the SQ indicator provided margins where investment return was expected to be maximized for second-hand dry bulk carriers and tankers. Also, optimization results indicated that when the SQ indicator's buy and sell signals were followed, the return was maximized within the given data set.

5.3.1 Dry Bulk Carrier

The optimization results were presented in Tables 5.1- 5.4 below, with the upper and lower levels to buy and sell ships according to different sizes of dry bulkers. While small size bulkers, Handysize, were optimized at 0.9 for a buy signal and 1.4 for a sell signal, large size bulkers, Capesize, were optimized at 0.8/buy and 1.1-1.2/ sell. This supported the argument that small dry bulkers are more volatile due to the high demand for their operational flexibility than larger vessels (Alizadeh et al., 2010). Moreover, the standard deviation of SQ_5 of dry bulkers decreased as the vessel size increased. Optimization results showed that the maximum return was obtained by Capesize, as investment increased, the return increased accordingly. Optimization results concluded a market timing strategy to obtain the maximum return on investment. For Handysize, it was indicated that 0.9 was the best level to buy and 1.4 to sell, the best level to maximize the return over the given period. While Panamax was optimized at the same level as Handysize, i.e., to buy at 0.9 and to sell at 1.4; Handymax was optimized at: to buy at 0.6 and to sell 1.1 level; and Capesize is optimized at: to buy at 0.8 and to sell at 1.1/1.2 level.

Of notice was that the 5-year- old Handysize ship was optimized at 0.9 to buy a second-hand vessel and to sell at 1.4 in the sample period from January 1995 to December 2015 (Table 5.1). The buy level for such a vessel was very close to level 1, which is the parity level, and the sell signal was considerably far from parity. It showed that the demand for a second-hand Handysize was significantly high, and there were investors in the market willing to pay an amount even higher than the nominal value of a Handysize.

According to Handysize SQ signals, the first buy signal came in February 1996, and the ship was purchased in May 1996, considering three months of buy/sell transaction gap. The ship was operated until May 2004, where three months after the first sell signal. From May 2004 to June 2012, SQ gave sell/ no action signals; the first buy signal started in

July 2012. After the first sell signal, the ship was purchased in October 2012 and sold in February 2014 after a sell signal. At the end of the sample period, there were no ships to sell or operate. Within this scenario, total income from selling the ship was US$33.50 million; the total operating income was US$13.52 million, the total expense to buy the ship was US$30.75 million. Hence the total profit was 16.3%.

Table 5.1. Optimization Results of SQ Handysize

BUY	*0.7*	*0.7*	*0.8*	*0.8*	*0.8*	*0.9*	*0.9*	*1.0*
SELL	*1.2*	*1.1*	*1.1*	*1.2*	*1.3*	*1.3*	*1.4*	*1.5*
SELL INCOME	*15.00*	*16.40*	*15.80*	*14.50*	*14.50*	*31.40*	*33.50*	*31.48*
OPERATION INCOME	*9.52*	*9.09*	*10.99*	*11.42*	*11.42*	*13.08*	*13.52*	*15.55*
BUY CASH OUTFLOW	*- 11.75*	*- 11.75*	*- 13.00*	*- 13.00*	*- 13.00*	*- 30.75*	*- 30.75*	*- 32.50*
CASH INFLOW	*24.52*	*25.49*	*26.79*	*25.92*	*25.92*	*44.48*	*47.02*	*47.02*
CASH OUTFLOW	*- 11.75*	*- 11.75*	*- 13.00*	*- 13.00*	*- 13.00*	*- 30.75*	*- 30.75*	*- 32.50*
FINAL	*12.77*	*13.74*	*13.79*	*12.92*	*12.92*	*13.73*	*16.27*	*14.52*
TOTAL	*112.77*	*113.74*	*113.79*	*112.92*	*112.92*	*113.73*	*116.27*	*114.52*
START	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*
TOTAL RETURN	***12.77%***	***13.74%***	***13.79%***	***12.92%***	***12.92%***	***13.73%***	***16.27%***	***14.52%***
Annualized	***0.64%***	***0.69%***	***0.69%***	***0.65%***	***0.65%***	***0.69%***	***0.81%***	***0.73%***

Source: Author

Handymax was optimized at 0.6 level to buy and 1.1 to sell the ship in the sample period from January 1995 to December 2015, as shown in Table 5.2. Following Handymax SQ signals, first, buy signal came in September 1998, and the ship was purchased in December 1998, operated until three months after the first sell signal in February 2004, and sold in May 2004. From May 2004 to September 2012, there was no buy signal. After the first buy signal in September 2012, the ship was purchased in December 2012 and operated until March 2014. At the end of the sample period, there were no ships to sell or operate. Within this scenario, the total income from selling ships was US$46.20 million; total operating income was US$15.60 million, total expense to buy ship was US$32.00 million, total profit is 29.8%. The optimized level 0.60 for a buy signal showed that the market price of Handymax could drop by 40% than its calculated price, which was a considerable gap between market price and the calculated price. While second-hand Handysize prices were less likely to go down, which was only 10% (at level 0.90), Handymax prices were more exposed downward price volatilities in the market. The sell level of Handymax was quite lower, level 1.10, which showed that the investor was quite impatient to sell Handymax to enjoy the increasing second-hand ship prices. On the other hand, if they would act patiently and wait until a certain level to sell Handymax, the optimized level to sell second-hand ship would be higher than the 1.10 level.

Table 5.2. Optimization Results of SQ Handymax

BUY	*0.7*	*0.8*	*0.6*	*0.6*	*0.7*	*0.8*	*0.8*	***0.6***
SELL	*1.2*	*1.3*	*1.2*	*1.3*	*1.1*	*1.1*	*1.2*	***1.1***
CAPITAL	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	***100.00***
SELL INCOME	*26.50*	*25.90*	*27.60*	*28.20*	*42.00*	*41.40*	*25.90*	***46.20***
OPERATION INCOME	*19.94*	*23.43*	*18.47*	*18.47*	*17.92*	*21.41*	*23.43*	***15.60***
BUY CASH OUTFLOW	*- 37.50*	*- 45.00*	*- 32.00*	*- 32.00*	*- 37.50*	*- 45.00*	*- 45.00*	***- 32.00***
CASH INFLOW	*46.44*	*49.33*	*46.07*	*46.67*	*59.92*	*62.81*	*49.33*	***61.80***
CASH OUTFLOW	*- 37.50*	*- 45.00*	*- 32.00*	*- 32.00*	*- 37.50*	*- 45.00*	*- 45.00*	***- 32.00***
FINAL	*8.94*	*4.33*	*14.07*	*14.67*	*22.42*	*17.81*	*4.33*	***29.80***
TOTAL	*108.94*	*104.33*	*114.07*	*114.67*	*122.42*	*117.81*	*104.33*	***129.80***
START	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	***100.00***

TOTAL RETURN	***8.94%***	***4.33%***	***14.07%***	***14.67%***	***22.42%***	***17.81%***	***4.33%***	***29.80%***
Annualized	***0.45%***	***0.22%***	***0.70%***	***0.73%***	***1.12%***	***0.89%***	***0.22%***	***1.49%***

Source: Author

Panamax was optimized at 0.9 level to buy and 1.4 to sell the ship in the sample period from January 1995 to December 2015, as shown in Table 5.3. The buy level for Panamax 5-year-old was also very close to level 1, which was the parity level, and the sell signal was considerably far from parity. Similar to Handysize, this indicated that the demand for second-hand Panamax was relatively high, and there were investors in the market who were willing to pay an amount, which was even higher than the nominal value of Panamax.

Following Panamax SQ signals, the first buy signal came in March 1995, and the ship was purchased in June 1995, operated until three months after the first sell signal in February 2004, and sold in May 2004. From May 2004 to May 2011, there was no buy signal. After the first buy signal in May 2011, the ship was purchased in August 2011 and operated until the end of the sample period in December 2015 and sold at the corresponding second-hand price in the market. Within this scenario, the total income from selling ships was US$28.57 million; total operating income was US$29.79 million, total expense to buy ship was US$22.50 million, total profit is 35.9%. The signal captured for Panamax was the same as Handysize, which showed that the investors were not willing to wait, and they preferred to buy the second-hand Panamax vessel once its market price went down by 10%. To sell the Panamax, the investor waited until level 1.40. This interval showed that the investors acted patiently to sell the Panamax and waited until a certain level with expectation of the price increase.

Table 5.3. Optimization Results of SQ Panamax

BUY	*0.7*	*0.7*	*0.8*	*0.8*	*0.7*	*0.8*	***0.9***	*1.0*
SELL	*1.2*	*1.1*	*1.2*	*1.1*	*1.3*	*1.3*	***1.4***	*1.4*
CAPITAL	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	***100.00***	*100.00*
SELL INCOME	*33.90*	*33.90*	*33.20*	*33.20*	*33.90*	*31.23*	***28.57***	*26.40*
OPERATION INCOME	*25.58*	*25.58*	*26.88*	*26.88*	*25.58*	*26.88*	***29.79***	*43.23*
BUY CASH OUTFLOW	*- 46.50*	*- 46.50*	*-49.00*	*-49.00*	*-46.50*	*-49.00*	***-22.50***	*- 51.50*
CASH INFLOW	*59.48*	*59.48*	*60.08*	*60.08*	*59.48*	*58.10*	***58.36***	*69.63*
CASH OUTFLOW	*- 46.50*	*-46.50*	*-49.00*	*- 49.00*	*- 46.50*	*-49.00*	***-22.50***	*-51.50*
FINAL	*12.98*	*12.98*	*11.08*	*11.08*	*12.98*	*9.10*	***35.86***	*18.13*
TOTAL	*112.98*	*112.98*	*111.08*	*111.08*	*112.98*	*109.10*	***135.86***	*118.13*
START	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	***100.00***	*100.00*
TOTAL RETURN	***12.98%***	***12.98%***	***11.08%***	***11.08%***	***12.98%***	***9.10%***	***35.86%***	***18.13%***
Annualized	***0.65%***	***0.65%***	***0.55%***	***0.55%***	***0.65%***	***0.46%***	***1.79%***	***0.91%***

Source: Author

The Capesize was optimized at 0.8 level to buy and two points, 1.1 and 1.2, to sell the ship in the sample period from January 1995 to December 2015, as shown in Table 5.4. Following the Capesize SQ signals, the first buy signal came in June 1995, and the ship was purchased in September 1995, operated until three months after the first sell signal (1.1) in January 2005 and sold in April 2005. From April 2005 to November 2008, there was no buy signal. After the first buy signal in November 2008, the ship was purchased in February 2009 and operated until the end of the sample period in December 2015 and sold at the corresponding second-hand price in the market. Within this scenario, the total income from selling the ship was US$53.50 million; total operating income was US$94.72 million; the total expense to buy ship was US$78.83 million. Hence the total profit was 69.39%. In the second sell signal level, 1.2, buy and sell time did not change. The interval captured for Capesize was quite narrow, which showed that the buy and sell signals were not so far from equilibrium level 1.00. This supported the argument that the demand for larger vessels was quite stable and mostly moved around the market price.

Table 5.4. Optimization Results of SQ Capesize

BUY	*0.7*	***0.8***	*0.9*	*1.0*	*0.6*	***0.8***	*0.7*
SELL	*1.2*	***1.1***	*1.3*	*1.4*	*1.0*	***1.2***	*1.1*
CAPITAL	*100.00*	***100.00***	*100.00*	*100.00*	*100.00*	***100.00***	*100.00*
SELL INCOME	*53.50*	***53.50***	*51.00*	*51.50*	*60.30*	***53.50***	*55.90*
OPERATION INCOME	*92.61*	***94.72***	*97.00*	*98.99*	*67.38*	***94.72***	*90.81*
BUY CASH OUTFLOW	*- 78.83*	***- 78.83***	*- 80.46*	*- 83.71*	*- 73.00*	***- 78.83***	*- 78.83*
CASH INFLOW	*146.11*	***148.22***	*148.00*	*150.49*	*127.68*	***148.22***	*146.71*
CASH OUTFLOW	*- 78.83*	***- 78.83***	*- 80.46*	*- 83.71*	*- 73.00*	***- 78.83***	*- 78.83*
FINAL	*67.28*	***69.39***	*67.54*	*66.78*	*54.68*	***69.39***	*67.87*
TOTAL	*167.28*	***169.39***	*167.54*	*166.78*	*154.68*	***169.39***	*167.87*
START	*100.00*	***100.00***	*100.00*	*100.00*	*100.00*	***100.00***	*100.00*
TOTAL RETURN	***67.3%***	***69.4%***	***67.5%***	***66.8%***	***54.7%***	***69.4%***	***67.9%***
Annualized	***3.36%***	***3.47%***	***3.38%***	***3.34%***	***2.73%***	***3.47%***	***3.39%***

Source: Author

Dry bulk carrier SQ indicator optimization showed that to obtain highest annual return, the most profitable level of SQ to buy second-hand Handysize is at the level of 0.90, 0.60 for Handymax, 0.90 for Panamax, 0.80 for Capesize; while the most profitable level of SQ to sell second-hand Handysize was at the level of 1.40, 1.10 for Handymax, 1.40 for Panamax, 1.10 and 1.20 for Capesize. Following the optimized levels to buy and sell dry bulk carriers, the annual return was determined as 0.81% for Handysize, 1.49% for

Handymax, 1.79% for Panamax, and 3.47% for Capesize. The optimization results of dry bulk carriers have been illustrated as in below Figure 5.1.

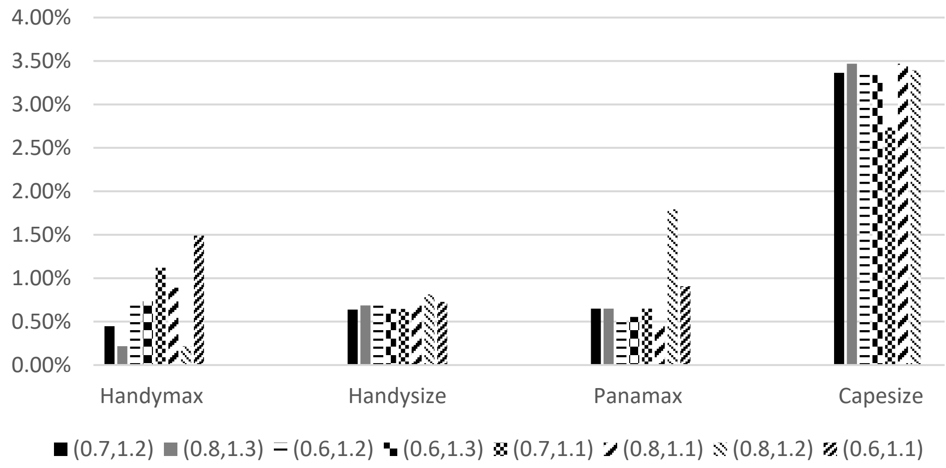


Figure 5.1: Dry Bulk SQ Optimization (Yearly Return)

5.3.2 Tanker Carrier

The optimization results were presented in Tables 5.5- 5.8 below, with the upper and lower levels to buy and sell ships according to different sizes of tankers. The SQ monthly results for tanker vessels generally tend to stay below level 1.00, which was mainly due to inelastic product (e.g., oil) demand and the recent changes in ownership structure. As discussed in the previous chapters, these two fundamental reasons affected the pricing of the second-hand tanker vessels. Therefore, optimization subject to investment return was critical for tanker vessels to reveal more accurate buy/sell levels. Moreover, the upper and lower bands to maximize the return of investment did not show significant differences from the reported levels. The intervals were mostly close to each other, which shows that there was a stable demand for the tanker vessels. Meanwhile, this impeded the SQ from reaching out to extremely lower and upper levels.

The product tanker was optimized at 0.50 level to buy, and at 0.70 level to sell the ship in the sample period from January 1995 to December 2015, as shown in Table 5.5.

Following the product tanker SQ signals, the first buy signal came in October 1998, and the ship was purchased in January 1998, operated until three months after the first sell signal (0.70) in July 2007 and sold in October 2007. From October 2007 to November 2008, there was no buy signal. After the first buy signal in November 2008, the ship was purchased in February 2009 and operated until the end of the sample period in December 2015 and sold at the corresponding second-hand price in the market. Within this scenario, the total income from selling the ship was US$46.57 million, and the total operating income was US$69.38 million; the total expense to purchase the ship was US$50.25 million. Hence the total profit was 65.70% over the sample period. The optimization results of the product tanker showed that the optimized level to buy a ship was quite lower than the equilibrium level 1.00, which showed that there is a significant gap between the calculated price of the product tanker and the market price. This supported the argument that the demand was quite inelastic towards tanker services. Within the stable supply and demand conditions, the optimized level to buy and sell tanker was confined to the inelastic demand condition in the market.

Table 5.5. Optimization Results of SQ Product Tanker

BUY	***0.50***	*0.50*	*0.50*	*0.45*
SELL	***0.70***	*0.60*	*0.65*	*0.65*
CAPITAL	***100.00***	*100.00*	*100.00*	*100.00*
SELL INCOME	***46.57***	*41.22*	*41.44*	*41.44*
OPERATION INCOME	***69.38***	*48.24*	*50.77*	*37.65*
BUY CASH OUTFLOW	***- 50.25***	*- 50.25*	*- 50.25*	*-51.09*
CASH INFLOW	***115.95***	*89.46*	*92.21*	*79.09*
CASH OUTFLOW	***- 50.25***	*- 50.25*	*- 50.25*	*-51.09*
FINAL	***65.70***	*39.21*	*41.96*	*28.00*
TOTAL	***165.70***	*139.21*	*141.96*	*128.00*
START	***100.00***	*100.00*	*100.00*	*100.00*

TOTAL RETURN	***65.70%***	***39.21%***	***41.96%***	***28.00%***
Annualized	***3.29%***	***1.96%***	***2.10%***	***1.40%***

Source: Author

The Aframax tanker was optimized at 0.50 level to buy, and at 0.80 level to sell the ship in the sample period from January 1995 to December 2015, as shown in Table 5.6. Following the Aframax SQ signals, the first buy signal came in November 1998, and the ship was purchased in February 1999, operated until three months after the first sell signal (0.80) in May 2005 and sold in August 2005. From August 2005 to December 2008, there was no buy signal. After the first buy signal in December 2008, the ship was purchased in March 2009 and operated until the end of the sample period in December 2015 and sold at the corresponding second-hand price in the market. Within this scenario, the total income from selling the ship was US$68.85 million, and the total operating income was US$68.77 million; the total expense to purchase the ship was US$74.00 million; hence the total profit was 60.25% over the sample period. The optimization interval for Aframax indicated the most considerable difference among the tanker vessels, which was 0.30. It showed that the investors would be quite more patient to sell Aframax compared to the other three vessel types. They might prefer to wait until a certain price level to sell their vessel.

Table 5.6. Optimization Results of SQ Aframax

BUY	*0.50*	***0.50***	*0.45*	*0.45*
SELL	*0.70*	***0.80***	*0.70*	*0.80*
CAPITAL	*100.00*	***100.00***	*100.00*	*100.00*
SELL INCOME	*109.80*	***68.85***	*104.45*	*69.49*
OPERATION INCOME	*50.45*	***68.77***	*46.88*	*68.44*
BUY CASH OUTFLOW	*- 100.00*	***- 74.00***	*- 103.50*	*- 74.50*
CASH INFLOW	*160.25*	***137.62***	*151.33*	*137.93*

CASH OUTFLOW	*- 100.00*	***- 74.00***	*- 103.50*	*- 74.50*
FINAL	*60.25*	***63.62***	*47.83*	*63.43*
TOTAL	*160.25*	***163.62***	*147.83*	*163.43*
START	*100.00*	***100.00***	*100.00*	*100.00*
TOTAL RETURN	***60.25%***	***63.62%***	***47.83%***	***63.43%***
Annualized	***3.01%***	***3.18%***	***2.39%***	***3.17%***

Source: Author

The Suezmax tanker was optimized at 0.60 level to buy, and at 0.70 level to sell the ship in the sample period from January 1995 to December 2015, as shown in Table 5.7. The buy and sell signal gap was quite narrow in the Suezmax tanker, which highly limits asset play opportunities. Following the Suezmax SQ signals, the first buy signal was received in October 1998, and the ship was purchased in January 1999, operated until three months after the first sell signal (0.70) in March 2000 and sold in June 2000. The first buy signal was received in August 2001, and the ship was purchased in November 2001. After the first buy signal in August 20001, the ship was operated until three months after the first sell signal in May 2005, which was sold in August 2005. The following buy signal was obtained in October 2008, and in January 2009, the ship was purchased and operated until the end of the sample period in December 2015 and sold at the corresponding second-hand price in the market. Within this scenario, the total income from selling the ship was US$144.58 million; the total operating income was US$85.24 million; the total expense to purchase the ship was US$148.00 million. Hence the total profit was 81.80% over the sample period. The optimized level to buy and sell Suezmax was significantly limited to the inelastic demand for tanker services. The interval between buy and sell was only 0.10. Also, it showed that the investors were not quite sensitive to the price changes in the second-hand tanker market; they were keen to invest regardless of the price.

Table 5.7. Optimization Results of SQ Suezmax

BUY	***0.60***	*0.50*	*0.55*
SELL	***0.70***	*0.70*	*0.65*
CAPITAL	***100.00***	*100.00*	*100.00*
SELL INCOME	***144.58***	*104.25*	*104.00*
OPERATION INCOME	***85.24***	*70.68*	*76.47*
BUY CASH OUTFLOW	***- 148.00***	*- 103.00*	*- 111.00*
CASH INFLOW	***229.82***	*174.93*	*180.47*
CASH OUTFLOW	***- 148.00***	*- 103.00*	*- 111.00*
FINAL	***81.82***	*71.93*	*69.47*
TOTAL	***181.82***	*171.93*	*169.47*
START	***100.00***	*100.00*	*100.00*
TOTAL RETURN	***81.82%***	***71.93%***	***69.47%***
Annualized	***4.09%***	***3.60%***	***3.47%***

Source: Author

The VLCC tanker was optimized at 0.60 level to buy, and at 0.70 level to sell the ship in the sample period from January 1995 to December 2015, as shown in Table 5.8. The buy and sell signal gap was quite narrow in the VLCC tanker, which highly limits asset play opportunities. Following the VLCC SQ signals, the first buy signal was received in September 1998, and the ship was purchased in December 1998, operated until three months after the first sell signal (0.70) in May 2000, and sold in August 2000. The first buy signal was received in August 2001, and the ship was purchased in November 2001. After the first buy signal in August 2001, the ship was operated until three months after the first sell signal in March 2005, which was sold in June 2005. The following buy signal was delivered in October 2008, and in January 2009, the ship was purchased and operated until the end of the sample period in December 2015 and sold at the corresponding second-hand price in the market. Within this scenario, the total income from selling the ship was US$213.77 million; the total operating income was US$117.55 million; the total expense to purchase the ship was US$204.00 million. Hence the total profit was 127.30% over the sample period. Also, the narrow interval issue appeared in VLCC optimization results, which indicated that the investors tended to be more impatient to invest regardless of price changes; they were keen to invest.

Table 5.8. Optimization Results of SQ VLCC

BUY	*0.50*	***0.60***	*0.60*
SELL	*0.70*	***0.70***	*0.72*
CAPITAL	*100.00*	***100.00***	*100.00*
SELL INCOME	*155.38*	***213.77***	*125.14*
OPERATION INCOME	*95.05*	***117.55***	*136.80*
BUY CASH OUTFLOW	*- 149.00*	***- 204.00***	*- 145.00*
CASH INFLOW	*250.43*	***331.32***	*261.94*
CASH OUTFLOW	*- 149.00*	***- 204.00***	*- 145.00*
FINAL	*101.43*	***127.32***	*116.94*
TOTAL	*201.43*	***227.32***	*216.94*
START	*100.00*	***100.00***	*100.00*
TOTAL RETURN	***101.43%***	***127.32%***	***116.94%***
Annualized	***5.07%***	***6.37%***	***5.85%***

Source: Author

Tanker carrier SQ indicator optimization showed that to obtain a highest annual return, the most profitable level to buy Product tanker is at the level of 0.50, 0.50 for Aframax, 0.60 for Suezmax, 0.60 for VLCC; while the most profitable level to sell Product tanker was at the level of 0.70, 0.80 for Aframax, 0.70 for Suezmax, 0.70 for VLCC. Following the optimized level to buy and sell tanker carriers, the annual return were determined as 3.29% for Product tanker, 3.18% for Aframax, 4.09% for Suezmax, and 6.37% for VLCC. The optimization results of tanker carriers have been illustrated as in below Figure 5.2.

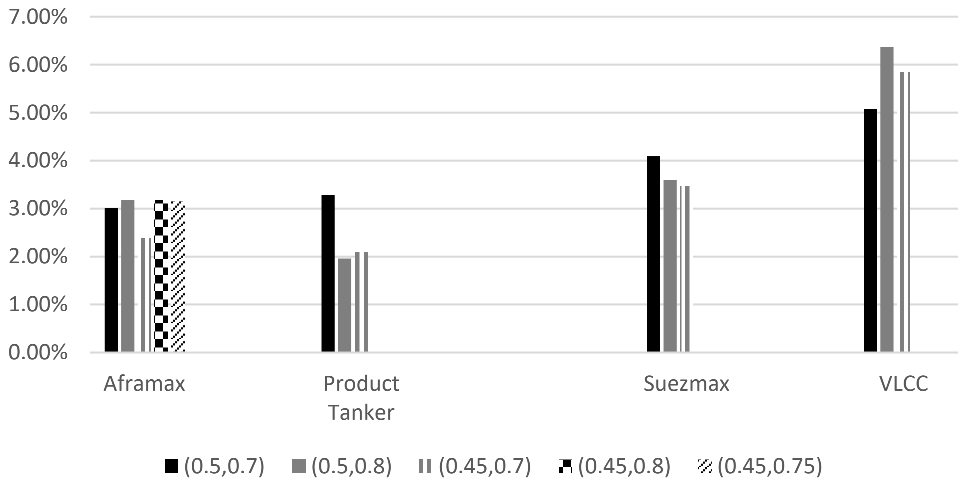


Figure 5.2: Tanker SQ Optimization (Yearly Return)

5.4 Summary

Chapter 5 shed light on the optimization of the monthly SQ indicator. The results provided robust and significant information about the lower and upper bands of optimization for the dry bulker and tanker vessels. In particular, Section 5.2 explained the steps of the SQ optimization process. In Section 5.3, optimization results were discussed separately for dry bulker and tanker vessels. They both provided extensive information about the optimized level subject to investment returns. Investors tended to be more patient in dry bulker investment and wait until the desired level to sell the vessel, while in tanker investments, they mostly behaved impatiently to take action. Consequently, this chapter helped to identify exact buy and sell levels for dry bulker and tanker vessels rather than using equilibrium level assumptions.

Chapter 6 Conclusion

6.1 Introduction

This thesis analysed the major investment theories and their applicability to ship investments, in particular dry bulk and tanker carriers. The study necessitated an extensive analysis of the key literature in the field of firm-level investment theories, ship investments, and asset valuation. To answer the research questions below, this study developed an indicator based on the foundation of the Tobin Q model and applied it to second-hand dry bulk and tanker carrier investments. The SQ indicator produced information regarding investment timing. SQ indicator was then optimized subject to investment return and the lower and upper levels identified for dry bulk and tanker carriers.

PRQ: How can second-hand ships be evaluated with conventional investment modeling to detect over and undervaluation?

SRQ1: What is the foundation of the major investment theories that apply to second-hand ship investments?

SRQ2: How can the chosen investment model be adapted to the second-hand dry bulk and tanker carrier on a yearly and monthly basis?

SRQ3: How can the identified investment model be optimized for the second-hand dry bulk and tanker carrier investments subject to investment return?

The following sections are organized as: the main findings are provided in Section 6.2, and the contributions of the thesis are summarized in Section 6.3. Finally, Section 6.4 presents limitations and recommendations for future research.

6.2 Main Findings

The main finding of the thesis is the SQ indicator. SQ was produced with well-known techniques, including NPV, income-based asset valuation, the firm-level investment theory, and Tobin Q model. SQ indicator was calculated as a ratio of the market value of a ship to a nominal value of a ship. The nominal value of a ship was calculated by the long-term value of a ship, which utilized the income-based approach. Consequently, the SQ indicator compared the market value of a ship and calculated the nominal value of a ship, which indicated downs and ups in the freight market and second-hand ship prices. The uniqueness of the SQ indicator comes from the approach utilized in the calculation of the indicator, which has not previously been applied in the shipping markets. The previous approaches applied to the shipping investment tend to be more static, rather than dynamic valuation applied in the calculation of the SQ indicator. Moreover, the optimization of the monthly SQ indicator led to revealing the more precise level of maximizing the return on investment. As a result, the main findings can be summarized in two parts: the first part is the theoretical findings based on the literature review, and the second part is the empirical findings, the main outcome of the SQ indicator, and the optimization results of the indicator.

6.2.1 Findings from Literature Review

The comprehensive review of the major investment theories and ship investment literature was elaborated to address Research Question 1. In Chapter 2, two major contributions to major investment theories and ship investments have been provided. Firstly, the comprehensive review of the major investment theories, along with their main features and critiques, have been evaluated. Secondly, the literature on ship investments, in particular, to reveal existing literature in the context of second-hand and freight market relationships by two main vessel types, dry bulk, and tanker carriers, have been investigated.

The firm-level investment theories have shown continuous advancements to identify the maximum level of firm value by dissolving the drawbacks of the previous investment models throughout the 1900s to 1970s. Indeed, five mainstream theories including accelerator (Chenery, 1952; Goodwin, 1948), expected profit (Grunfeld, 1960), liquidity (Kuh, 1963), neoclassical (Jorgenson et al., 1968) and Q theory (Brainard et al., 1968; Tobin, 1969, 1978), indicated that most of the investment theories deal with determinants of investments by assuming either instantaneous adjustment or distributed lag structure which was not related to any optimisation process. The latest and advanced Q theory was the only exception which contains theoretical foundations to allow a study of investment determinants in accordance with the economic relationship. This allowed gathering more plausible output by capturing broader information on investment and economic relationships.

In the literature, major investment theories have previously been applied to various industries, such as manufacturing, finance, banking, housing, and airline; and most of the studies proved that the explanatory power of investment theories could not be ignored. In the shipping industry, the application of major investment theories was not widely adopted. Previous ship investment literature mostly analysed the relationship among the shipping markets (newbuilding, second-hand, freight, and scrap) and their individual/multiple impacts on asset price valuation, the timing of investments, and market entry and exit conditions. Although the industry is highly capital intensive and attracts a high amount of investment, insufficient research has been undertaken focusing on maximising the firm/industry value by reaching an optimum level and asset price valuation. The existing firm-level investment theories require adaptation to explain the investment decision by shipowners. Particularly given the market structures of the dry bulk and tanker market, the decision could be driven more by expectations of future market conditions rather than asset prices and financial market conditions. This was supported by the existing studies, which focus on asset prices and the ratio of new and second-hand ships, which was an indication of future expectations rather than an evaluation of a firm's value.

In the context of existing literature on ship investments, further research should have been undertaken to investigate the decision-making process on ship investments through firm-level investment theories to examine the industry with the microeconomic approach. Utilizing investment theories could produce comprehensive findings to define firm-level value maximisation within the approach of robust investment theories. Therefore, each firm could take advantage of defining the maximum level of firm value to manage investment funds in the long run. With the extensive theoretical foundation of major firm-level investment theories and the literature of ship investments, the application of the modified Q model in the shipping industry could be more feasible.

6.2.2 Findings from Empirical Application

The empirical results of this thesis were aimed to address Research Questions 1 and 2 with the development of the SQ indicator to reveal the disparity between the market value and the nominal value of a ship and interpret the results for the utilization of the SQ indicator on investment decisions.

With the application of the Tobin Q model, this thesis aimed to fill this gap and create an innovative way to interpret freight and second-hand market signals. Indeed, the SQ indicator resolved the “buy low and sell high” approach and formulate it to apply in the asset management system. To produce the SQ indicator, the Tobin Q variable, the ratio of a market value of an asset to the replacement cost of an asset, was translated into the SQ indicator as a ratio of the market value of a ship to the nominal value of a ship. The SQ indicator captured over and undervaluation of a ship acting as a signal for sale or purchase based on market price and long-term nominal value of SH ship, shedding light on the ship investment timing. SQ indicator was analysed within yearly and monthly forms. The yearly results provided the solid ground to deepen the research within the price-value disparity between the market price and the long-term nominal value of second-hand ships. Notably, the snowballing gap between market price and long-term nominal value of second-hand ships between 2003 and 2008 encouraged to monitor further monthly SQ changes, which presented a more in-depth view of price changes in the second-hand ship market. In both dry bulker and tanker carriers, the SQ indicator sell signals were followed by a price decrease in second-hand and freight rate markets; and buy signals were followed by a price increase in second-hand and freight rate markets.

Secondly, the thesis aimed to optimize monthly SQ to obtain a more precise level of investment return maximization. The optimization was illustrated within a specific period, from 1995 until 2015, for both dry bulker and tanker 5-year-old second-hand ships. The optimization results revealed the exact level of buy and sell for dry bulker and tanker carriers to maximize the investment returns. In such a capital-intensive industry, optimization results could be utilized at the most efficient level in shipping asset management. Especially, empirical findings of the SQ tanker optimization carried the highest importance, since the SQ tanker indicator was mostly below the equilibrium level. The findings from the optimization process highlighted the approximate upper and lower level to maximize ship investment returns on tanker carrier investment. The interval was quite narrow in tanker optimization, whereas, dry bulk optimization mostly indicated an expanded upper and lower level of optimization to buy and sell ships. This provided a considerable time to think for dry bulk buyers since buy and sell signal intervals were quite broad. For the tanker buyers, the gap between sell and buy options was quite narrow. Therefore, this led the buyer and seller to decide quickly. Under these conditions, the SQ indicator stands out as a robust and significant tool to explore market entry and exit timings through the discrepancy between market prices and the long-term nominal value of shipping assets.

6.3 Contributions of the Thesis

This thesis has provided several contributions to the theoretical and empirical literature of maritime economics, in particular, ship investment management through an algorithm, which have not received substantial attention in the literature.:

1. ***Literature***: Highlighted the gap in the literature with regards to the ship investment decision management.
2. ***SQ Indicator Development***: Adapted the investment theories to the ship investments with a contemporary approach.
3. ***Optimization of SQ Indicator***: Optimized the rule-based asset management tool (SQ) to obtain a lower and upper investment return maximization.

The contributions to maritime literature could be explained from various perspectives. Firstly, the literature from 1940 to 2018 was examined in relation to investment models, ship investments, and investment decisions approach in the shipping industry. A considerable gap in the literature of ship investments concerning the valuation of the ships by considering the price disparity between the market prices and the nominal prices of the ship were identified. This thesis has provided a new understanding of the valuation of the ship, price disparity between the market price and the nominal price of a ship, which contributed to the knowledge of shipping asset management. Secondly, the thesis established a strong conceptual link between major firm-level investment theories and ship investments. Through linking these two deep-rooted concepts, the thesis emphasized a neglected field in maritime economics and revealed the importance of applying one of the major investment models to ship investments. The thesis has also advanced the understanding of the valuation of ships along with the predictability of the markets.

The contribution of the thesis concerning the SQ indicator development in ship investments has proven that the upper and lower levels of price changes in second-hand ship prices could be identified through calculating the price disparity between the market price and the nominal price. In a highly dynamic investment environment, having a robust tool to reveal the valuation discrepancy in the shipping industry would provide a significant valuation insight for market participants to increase the use of funds through providing proper investment timing guidance. The SQ indicator provided profoundly insightful information about the cross-correlation relationship between second-hand ship prices and freight rates. The results highlighted the importance of considering the valuation mismatches between the market price of a ship and the nominal value of a ship in order to avoid the inefficient use of financial funds during the peak level of freight rates.

Optimization of the SQ indicator subject to the maximum investment return has provided a firm interval to identify approximate upper and lower bands where the SQ indicator was maximized. To illustrate the optimization of the SQ indicator, the simulation scenario was designed for each vessel type. The findings from this optimization process made several contributions to the current literature. First, the findings from the SQ indicator converted to the more approximate interval to conduct shipping asset management in a tested upper and lower levels to maximize investment return. This led to the consequences to benefit from the upper, and lower bands in the SQ signified overbought and oversold levels, respectively. Results of SQ identified mispricing, which in turn would lead to asset play opportunity. Especially, for tanker carriers, optimization of the SQ indicator carried the highest importance, since the SQ indicator of tanker carriers rarely went above the equilibrium level. This is explained by both the demand for and supply of tanker services are price inelastic in the short run due to the product carried by the tanker in the short term. Moreover, the tanker freight rate volatility is lower in the long run and generally shows sudden peaks, which incarcerates tanker SQ indicator below level 1.00 and locks the movement of the indicator in a narrow band. It is not reasonable to apply a standard equilibrium approach to interpret the movement of the tanker SQ indicator. Therefore, applying optimization steps to the tanker carrier facilitated to obtain further insights into the tanker market rather than only considering the equilibrium level approach. This provided a more approximate level to maximize investment return, and thus, optimization led to a consideration of the dynamics of the tanker market and addressed the market-specific structure.

6.4 Limitations and Recommendation for Future Research

There are several limitations needed to be considered. Firstly, SQ is a 'predictive' indicator of potentially biased prices (over/under-valuation). The predictive exercises are naturally asymmetric information. When a prediction is publicly accessible, then all players will change their behaviour, which is initially assumed in the predictive exercise. This 'reflexivity' rule would apply to the SQ application. In theory, it is assumed that the decision-maker (using SQ) is isolated from disturbances of such herd behaviour. In fact, all predictive studies in academia implicitly assume this. The economic actor with asymmetric information is an observer to realised valuations knowing that no prices and valuations are accurate prices and valuations of the asset. Prices and valuations could be approximations of truth or biased prices of untruth. Still, it cannot be claimed that SQ is a perfect reflection of truth. However, it is a relatively significant indicator of asset bubbles, which can be utilized for investment timing and asset play strategies.

Secondly, the SQ indicator was developed only at the industry-level due to the unavailability of firm-level data, which inherently limits the applicability of the SQ indicator to the firm-level analysis. Further studies regarding firm-level analysis are highly recommended in case of accessibility of the data.

Thirdly, in this thesis, the application of investment theories has been analysed, and adaptation of the firm-level investment model was applied to the dry bulk and tanker markets. However, a new theory has not been suggested in this thesis.

Fourthly, the SQ indicator optimization is merely tested for 5-years-old vessels of dry bulk and tanker carriers due to insufficient data for 10- and 15-years old vessels. Future research is highly recommended to run the optimization analysis for 10- and 15-years old vessels to contribute to second-hand market researches.

Lastly, for future researches, SQ indicator analysis is highly recommended to be applied to the newbuilding market to illustrate the disparity between the market price and the nominal price.

There are several recommendations that could be considered in future researches, which have not been exercised in this thesis due to limitations. The first recommendation is back-testing the predictability of SQ indicator with various methods; such as newbuilding price of the ship can be used as the nominal price of a ship and market price of the ship can be the second-hand price of the ship and SQ could be re-calculated to compare two indicator's predictability.

The second recommendation is to analyse the effectiveness of the SQ indicator for different ship types, such as container ships. This would reveal container market insights with the newly proposed model.

REFERENCES

Abel, A. B. (2015). *The analytics of investment, q, and cash flow*. Retrieved from

Abel, A. B., & Eberly, J. C. (1994). A unified model of investment under uncertainty. *84*.

Ådland, A. O., & Koekebakker, S. (2004). Market efficiency in the second-hand market for bulk ships. *Maritime Economics & Logistics, 6*(1), 1-15.

Adland, R., & Strandenes, S. (2006). Market efficiency in the bulk freight market revisited. *Maritime Policy & Management, 33*(2), 107-117.

Alizadeh, A., & Nomikos, N. (2006). Trading strategies in the market for tankers. *Maritime Policy & Management, 33*(2), 119-140.

Alizadeh, A., & Nomikos, N. (2007). Investment timing and trading strategies in the sale and purchase market for ships. *Transportation Research Part B: Methodological, 41*(1), 126-143.

Alizadeh, A., & Nomikos, N. (2010). An overview of the dry bulk shipping industry. *The Handbook of Maritime Economics and Business*, 319-354.

Anderson, W. H. L. (1964). *Corporate finance and fixed investment: an econometric study*. Boston: Division of Research, Graduate School of Business Administration, Harvard University.

Andrews, D. (2015). Natural price and the long run: Alfred Marshall's misreading of Adam Smith. *Cambridge Journal of Economics, 39*, 265-279.

Arevalo, A., Nino, J., Leon, D., Hernandez, G., & Sandoval, J. (2018). Stock Returns Prediction using Deep Neural Networks and Wavelets on High-Frequency Data. *IEEE COMPUTATIONAL INTELLIGENCE MAGAZINE*.

Armeanu, D., & Lache, L. (2009). The NPV criterion for valuing investments under uncertainty. *Economic Computation and Economic Cybernetics Studies and Research, 4*, 43.

Baddeley, C. (2002). Investment in an uncertain world. *Zagreb International Review of Economics and Business, 5*(2), 1-21.

Baum, A., Baum, C. M., Nunnington, N., & Mackmin, D. (2013). *The income approach to property valuation*: Estates Gazette.

Bendall, H., & Stent, A. (2007). Maritime investment strategies with a portfolio of real options. *Maritime Policy & Management, 34*(5), 441-452.

Berle, A. A., & Means, G. (1932). *The Modern Corporation and Private Property*. New York: Harcourt, Brace and World.

Blanchard, O., Rhee, C., & Summers, L. (1993). The stock market, profit, and investment. *The Quarterly Journal of Economics, 108*(1), 115-136.

Bodie, Z., Kane, A., & Marcus, A. J. (2014). *Investments* (Tenth Edition ed.). USA: Mc Graw Hill.

Bolton, P., Chen, H., & Wang, N. (2011). A unified theory of Tobin's q, corporate investment, financing, and risk management. *The journal of Finance, 66*(5), 1545-1578.

Bond, S., & Van Reenen, J. (2007). Microeconometric models of investment and employment. *Handbook of econometrics, 6*, 4417-4498.

Boyd, S., & Vandenberghe, L. (2004). *Convex optimization*: Cambridge university press.

Brainard, W., & Tobin, J. (1968). Pitfalls in financial model building. *The American Economic Review, 58*, 99-122.

Bulut, E., Duru, O., & Yoshida, S. (2013). Market entry, asset returns, and irrational exuberance: asset management anomalies in dry cargo shipping. *International Journal of Shipping and Transport Logistics, 5*(6), 652-667.
Caballero, R., Engel, E., Haltiwanger, J., Woodford, M., & Hall, R. (1995). Plant-level adjustment and aggregate investment dynamics. *Brookings papers on economic activity, 2*, 1-54.
Caporin, M., & Pelizzon, L. (2012). Market Volatility, Optimal Portfolios and Naive Asset Allocations.
Celik Girgin, S., Nguyen, H.-O., & Karlis, T. (2017). Revisiting the Effect of Financial Development on Economic Growth after 2008 Global Financial Crisis. *Advances in Economics and Business, 5*(8), 456-465.
Chamberlain, T., & Gordon, M. (1989). Liquidity, profitability, and long-run survival: theory and evidence on business investment. *Journal of Post Keynesian Economics, 11*(4), 589-610.
Chang, H.-J. (2014). *Economics: The User's Guide*. London: Penguin Group.
Chenery, H. (1952). Overcapacity and the acceleration principle. *Econometrica: Journal of the Econometric Society, 20*, 1-28.
Chirinko, R. S. (1993). Business fixed investment spending: Modeling strategies, empirical results, and policy implications. *Journal of Economic Literature, 31*(4), 1875-1911.
Chistè, C., & Van Vuuren, G. (2014). Investigating the cyclical behaviour of the dry bulk shipping market. *Maritime Policy & Management, 41*(1), 1-19.
Chung, K. H., & Pruitt, S. W. (1994). A simple approximation of Tobin's q. *Financial management*, 70-74.
Clark, J. (1917). Business acceleration and the law of demand: A technical factor in economic cycles. *Journal of Political Economy, 25*(3), 217-235.
Clark, J. (1932). Capital production and consumer-taking: A further word. *Journal of Political Economy, 40*(5), 691-693.
Dai, L., Hu, H., & Zhang, D. (2015). An empirical analysis of freight rate and vessel price volatility transmission in global dry bulk shipping market. *Journal of Traffic and Transportation Engineering (English Edition), 2*(5), 353-361. doi:10.1016/j.jtte.2015.08.007
Dikos, G. (2008). Real options econometrics for aggregate tanker investment decisions. *International Journal of Ocean Systems Management, 1*(1), 31-44.
Dikos, G., & Marcus, H. (2003). The Term Structure of Second-hand Prices: A Structural Partial Equilibrium Model. *Maritime Economics & Logistics, 5*(3), 251-267.
Dikos, G. N., & Thomakos, D. D. (2012). Econometric testing of the real option hypothesis: evidence from investment in oil tankers. *Empirical Economics, 42*(1), 121-145.
Dimitras, A. I., Petropoulos, T., & Constantinidou, I. (2002). Multi-criteria evaluation of loan applications in shipping. *Journal of Multi-Criteria Decision Analysis, 11*(4-5), 237-246.
Dixit, A., & Pindyck, R. (1994). *Investment under uncertainty*: Princeton university press.
Duru, O. (2013). Irrational exuberance, overconfidence and short-termism: knowledge-to-action asymmetry in shipping asset management. *The Asian Journal of Shipping and Logistics, 29*(1), 43-58.
Duru, O. (2016). Motivations behind irrationality in the shipping asset management. *Maritime Business Review, 1*(2), 163-184. doi:10.1108/mabr-05-2016-0008

Duru, O. (2018). *Shipping Business Unwrapped: Illusion, Bias and Fallacy in the Shipping Business*: Routledge.
Eisner, R., & Strotz, R. (1963). Commission on Money and Credit, Impacts of Monetary Policy. In *Determinants of Business Investment* Englewood Cliffs, N.J.: Prentice-Hall.
Eklund, J. (2013). *Theories of investment: a theoretical review with empirical applications.* Paper presented at the Swedish Entrepreneurship Forum.
Eklund, J. E. (2010). Q-theory of investment and earnings retentions—evidence from Scandinavia. *Empirical Economics, 39*(3), 793-813.
Espinoza, D., & Morris, J. W. (2013). Decoupled NPV: a simple, improved method to value infrastructure investments. *Construction management and economics, 31*(5), 471-496.
Fisher, I. (1907). *The Rate of Interest*. New York: Macmillan.
Fisher, I. (1930). *The Theory of interest rates*. New York: The Macmillan Company.
Foley, D. K. (2009). *Adam's fallacy: a guide to economic theology*: Harvard University Press.
Fortin, R., Michelson, S., Smith, S. D., & Weaver, W. (2007). Mortgage refinancing: the interaction of break even period, taxes, NPV, and IRR. *Financial Services Review, 16*(3), 197.
Fratini, S. M., & Naccarato, A. (2016). The gravitation of market prices as a stochastic process. *Metroeconomica, 67*(4), 698–716.
Gaspars-Wieloch, H. (2019). Project net present value estimation under uncertainty. *Central European Journal of Operations Research, 27*(1), 179-197.
Girgin, S. C., Karlis, T., & Nguyen, H.-O. (2018). A Critical Review of the Literature on Firm-Level Theories on Ship Investment. *International Journal of Financial Studies, 6*(11).
Gkochari, C. C. (2015). Optimal investment timing in the dry bulk shipping sector. *Transportation Research Part E: Logistics and Transportation Review, 79*, 102-109.
Glen, D. (1996). The econometric testing of investment incentives: A cointegrated approach.
Glen, D., & Christy, S. (2010). The Tanker Market: Current Structure and Economic Analysis. In C. Grammenos (Ed.), The Handbook of Maritime Economics and Business (pp. 355-390). London: Taylor and Francis.
Glen, D., & Martin, B. (2002). The Tanker Market: Current Structure and Economic Analysis. In C. Grammenos (Ed.), *Handbook of Maritime Economics and Business* (pp. 251-279). London: LLP.
Glen, D., Owen, M., & Van der Meer, R. (1981). Spot and Time Charter Rates for Tankers, 1970-77. *Journal of Transport Economics and Policy*, 45-58.
Glen, D. R. (1997). The market for second-hand ships: Further results on efficiency using cointegration analysis. *Maritime Policy and Management, 24*(3), 245-260.
Goodwin, R. (1948). Secular and Cyclical Aspects of the Multiplier and the Accelerator. In *Income, Employment and Public Policy*. New York: W.W. Norton & Co.
Gould, J. (1968). Adjustment Costs in the Theory of Investment of the Firm. *The Review of Economic Studies, 35*(1), 47-55.
Grunfeld, Y. (1960). *The determinants of corporate investment*. Chicago: University of Chicago Press.
Gugler, K., & Yurtoglu, B. B. (2003). Average q, marginal q, and the relation between ownership and performance. *Economics Letters, 78*(3), 379-384.

Gurley, J., & Shaw, E. (1955). Financial Aspects of Economic Development. *American Economic Review, 45*(4), 515-538.
Hall, R. E. (2001). The stock market and capital accumulation. *American Economic Review, 91*(5), 1185–1202.
Hansen, A. H. (1939). Economic progress and declining population growth. *The American Economic Review, 29*(1), 1-15.
Haralambides, H., Tsolakis, S., & Cridland, C. (2005). Econometric modelling of newbuilding and secondhand ship prices. *Research in Transportation Economics, 12*, 65-105.
Harlaftis, G. (2007). From Diaspora Traders to Shipping Tycoons The Vagliano Bros. *The Business History Review, 81*(2), 237-268.
Harlaftis, G., Tenold, S., & Valdaliso, J. M. (2012). Epilogue: A Key Industry or an Invisible Industry? In G. Harlaftis, S. Tenold, & J. Valdaliso (Eds.), *The World's Key Industry History and Economics of World Shipping* (pp. 263-272). UK: Palgrave Macmillan.
Hawdon, D. (1978). Tanker freight rates in the short and long run. *Applied Economics, 10*(3), 203-218.
Hayashi, F. (1982). Tobin's marginal q and average q: A neoclassical interpretation. *Econometrica: Journal of the Econometric Society, 50*, 213-224.
Hillebrand, E. (2003). A mean-reversion theory of stock-market crashes. *Journal of Finance, 41*, 591-601.
Himmelberg, C. P., Hubbard, R. G., & Palia, D. (1999). Understanding the determinants of managerial ownership and the link between ownership and performance. *Journal of Financial Economics, 53*(3), 353-384.
Hopp, C., & Tsolakis, S. D. (2004). *Investment applications in the shipping industry.* Paper presented at the Proceedings of the 8th Annual International Conference on Real Options.
Johar, K., Carmichael, D. G., & Balatbat, M. C. (2010). A study of correlation aspects in probabilistic NPV analysis. *The Engineering Economist, 55*(2), 181-199.
Jorgenson, D. (1963). Capital theory and investment behavior. *The American Economic Review, 53*(2), 247-259.
Jorgenson, D. (1967). The Theory of Investment Behavior. In R. Ferber (Ed.), *Determinants of investment behavior*. New York: NBER.
Jorgenson, D. (1971). Econometric studies of investment behavior: a survey. *Journal of Economic Literature, 9*(4), 1111-1147.
Jorgenson, D., & Siebert, C. (1968). A comparison of alternative theories of corporate investment behavior. *The American Economic Review, 58*, 681-712.
Kalecki, M. (1949). A new approach to the problem of business cycles. *The Review of Economic Studies, 16*(2), 57-64.
Karlis, T., Polemis, D., Girgin, S. C., & Syntychaki, A. (2019). *Future Challenges of Maritime Economics Research*. Paper presented at the IAME 2019 CONFERENCE, Greece.
Kavussanos, M., & Alizadeh, A. (2002). The expectations hypothesis of the term structure and risk premiums in dry bulk shipping freight markets. *Journal of Transport Economics and Policy (JTEP), 36*(2), 267-304.
Kavussanos, M. G. (1996). Comparisons of volatility in the dry-cargo ship sector: Spot versus time charters, and smaller versus larger vessels. *Journal of Transport Economics and Policy*, 67-82.

Kavussanos, M. G. (1997). The dynamics of time-varying volatilities in different size second-hand ship prices of the dry-cargo sector. *Applied Economics, 29*(4), 433-443.
Keynes, J. M. (1936). *The general theory of employment, interest and money*. London: Palgrave Macmillan.
Kilponen, J., & Verona, F. (2016). Testing the Q theory of investment in the frequency domain. *Bank of Finland Research Discussion Paper, 32*.
King, R., & Levine, R. (1993a). Finance and Growth: Schumpeter Might be Right. *The Quarterly Journal of Economics, 108*(3), 717-737.
King, R., & Levine, R. (1993b). Finance, Entrepreneurship and Growth: Theory and Evidence. *Journal of Monetary Economics, 32*, 513-542.
Klein, L. (1951). Studies in Investment Behavior. In *Conference on Business Cycles*. New York: NBER.
Klein, S. (2003). The Natural Roots of Capitalism and Its Virtues and Values. *Journal of Business Ethics, 45*, 387-401.
Kopcke, R. W. (1977). The Behavior of Investment Spending During the Recession and Recovery, 1973-76. *New England Economic Review*, 5-41.
Kopcke, R. W. (1982). Forecasting investment spending: the performance of statistical models. *New England Economic Review*, 13-32.
Kopcke, R. W. (1985). The determinants of investment spending. *New England Economic Review, 19*, 35.
Kopcke, R. W. (2001). The performance of traditional macroeconomic models of businesses' investment spending. *New England Economic Review*(2), 3.
Koyck, L. M. (1954). *Distributed lags and investment analysis*. Amsterdam: North-Holland Publishing Company.
Kuh, E. (1963). *Capital stock growth: A micro-econometric approach*. Amsterdam: North Holland Publishing Company.
Levine, R. (2004). Finance and Growth: Theory and Evidence. *NBER Working Paper, 10766*.
Li, M. Z., Oum, T. H., & Zhang, Y. (2004). Tobin's q and airline performances. *Public Works Management & Policy, 9*(1), 51-65.
Lindenberg, E. B., & Ross, S. A. (1981). Tobin's q ratio and industrial organization. *Journal of business*, 1-32.
Lorange, P. (2001). Strategic re-thinking in shipping companies. *Maritime Policy & Management, 28*(1), 23-32.
Lozinskaia, A., Merikas, A., Merika, A., & Penikas, H. (2017). Determinants of the probability of default: the case of the internationally listed shipping corporations. *Maritime Policy & Management, 44*(7), 837-858.
Lucas Jr, R. (1967). Adjustment costs and the theory of supply. *Journal of Political Economy, 75*(4, Part 1), 321-334.
Lun, Y. V., Hilmola, O.-P., Goulielmos, A. M., Lai, K.-h., & Cheng, T. E. (2012). *Oil transport management*: Springer Science & Business Media.
Luo, M., & Kou, Y. (2018). Market driven ship investment decision using the real option approach. *Transportation Research Part A: Policy and Practice, 118*, 714-729.
Marchioni, A., & Magni, C. A. (2018). Investment decisions and sensitivity analysis: NPV-consistency of rates of return. *European Journal of Operational Research, 268*(1), 361-372.
Marcus, H., Glucksman, M., Ziogas, B., & Meyer, K. (1991). A buy-low, sell-high investment methodology: the case of bulk shipping. *Interfaces, 21*(2), 8-21.

Marlow, P. (1991a). Shipping and investment incentives: a trilogy† Part 3. The effectiveness of investment incentives for shipping—the UK experience 1950–1987. *Maritime Policy and Management, 18*(4), 283-311.
Marlow, P. B. (1991b). Shipping and investment incentives: a trilogy. *Maritime Policy & Management, 18*(2), 123-138.
Marlow, P. B. (1991c). Shipping and investment incentives: a trilogy† Part 2. Investment incentives for shipping. *Maritime Policy and Management, 18*(3), 201-216.
McCloskey, D. N. (2002). *The secret sins of economics*. Chicago: Prickly Paradigm.
McCloskey, D. N. (2006). *Bourgeois Virtue*. Chicago: University of Chicago Press.
Merikas, A. G., Merika, A. A., & Koutroubousis, G. (2008). Modelling the investment decision of the entrepreneur in the tanker sector: choosing between a second-hand vessel and a newly built one. *Maritime Policy & Management, 35*(5), 433-447.
Meyer, J., & Glauber, R. (1964). *Investment decisions, economic forecasting, and public policy*. Boston: Division of Research, Harvard Business School.
Meyer, J., & Kuh, E. (1957). *The investment decision: An empirical study*. Cambridge: Harvard University Press.
Michael, J. C. (2015). Statistics an Introduction Using R. *John Wiley and Sons*.
Mihaljevic, J. (2010). *Equities and Tobin's Q*. Retrieved from USA:
Mihaljevic, J. (2013). *The Manual of Ideas*. In.
Miller, M., & Modigliani, F. (1961). Dividend policy, growth, and the valuation of shares. *the Journal of Business, 34*(4), 411-433.
Miller, M., & Modigliani, F. (1966). Some estimates of the cost of capital to the electric utility industry, 1954-57. *The American Economic Review, 56*(3), 333-391.
Mitchell, W. C. (1913). *Business cycles* (Vol. 3): University of California Press.
Morck, R., Shleifer, A., & Vishny, R. W. (1988). Management ownership and market valuation: An empirical analysis. *Journal of Financial Economics, 20*, 293-315.
Morgenstern, O., & Von Neumann, J. (1953). *Theory of games and economic behavior*: Princeton university press.
Nickell, S. (1978). *The investment decisions of firms*: Nisbet; Cambridge: Cambridge University Press.
OECD. (2001). *Regulatory issues in international maritime transport*. Retrieved from
Paine, L. (2014). *The sea and civilization: a maritime history of the world*: Atlantic Books Ltd.
Papapostolou, N., Pouliasis, P., & Kyriakou, I. (2017). Herd behavior in the drybulk market: an empirical analysis of the decision to invest in new and retire existing fleet capacity. *Transportation Research Part E: Logistics and Transportation Review, 104*, 36-51.
Papapostolou, N. C., Nomikos, N. K., Pouliasis, P. K., & Kyriakou, I. (2014). Investor sentiment for real assets: the case of dry bulk shipping market. *Review of Finance, 18*(4), 1507-1539.
Pires, F. C., Assis, L. F., & Fiho, M. R. (2012). A real options approach to ship investment appraisal. *African Journal of Business Management, 6*(25), 7397-7402.
Romer, D. (2006). *Advanced Macroeconomics*. New York: McGraw Hill/Irwin.
Rousos, E.-P., & Lee, B. S. (2012). Multicriteria analysis in shipping investment evaluation. *Maritime Policy & Management, 39*(4), 423-442.
Rua, A. (2011). A wavelet approach for factor - augmented forecasting. *Journal of Forecasting, 30*(7), 666-678.

Samuelson, P. (1939a). Interactions between the multiplier analysis and the principle of acceleration. *The Review of Economics and Statistics, 21*(2), 75-78.
Samuelson, P. (1939b). A Synthesis of the Principle of Acceleration and the Multiplier. *Journal of Political Economy, 47*(6), 786-797.
Samuelson, P. A. (1988). The Keynes-Hansen-Samuelson multiplier-accelerator model of secular stagnation. *Japan and the World Economy, 1*(1), 3-19.
Scarsi, R. (2007). The bulk shipping business: market cycles and shipowners' biases. *Maritime Policy & Management, 34*(6), 577-590.
Skjeggedal, E. (2012). *The Q Theory Model of Housing: A Macroeconomic Analysis of the Dynamics in the Norwegian Housing Market.* NORGES HANDELSHØYSKOLE, Norway.
Smith, A. (1776). *The Wealth of Nations, Book 1*.
Stopford, M. (2009). *Maritime economics 3e*: Routledge.
Stroebel, J. C., & Taylor, J. B. (2009). *Estimated impact of the Fed's mortgage-backed securities purchase program*. Retrieved from
Sweezy, P. M. (2004). Why Stagnation? *Monthly Review, 56*.
Tinbergen, J. (1938). Statistical evidence on the acceleration principle. *Economica, 5*(18), 164-176.
Tinbergen, J. (1939). *Statistical Testing of Business Cycle Theories: Part I: A Method and Its Application to Investment Activity*. Geneva.
Tobin, J. (1969). A general equilibrium approach to monetary theory. *Journal of money, credit and banking, 1*(1), 15-29.
Tobin, J. (1978). Monetary policies and the economy: the transmission mechanism. *Southern economic journal*, 421-431.
Tsiang, S.-C. (1951). Accelerator, theory of the firm and the business cycle. *The Quarterly Journal of Economics, 65*(3), 325-341.
Tsolakis, S., Cridland, C., & Haralambides, H. (2003). Econometric Modelling of Second-hand Ship Prices. *Maritime Economics & Logistics, 5*(4), 347-377. doi:10.1057/palgrave.mel.9100086
UNCTAD. (1990). *Review of Maritime Transport*. Retrieved from Geneva, Switzerland: https://unctad.org/en/PublicationsLibrary/rmt1990_en.pdf
UNCTAD. (1995). *Review of Maritime Transport*. Retrieved from Geneva, Switzerland: https://unctad.org/en/PublicationsLibrary/rmt1995_en.pdf
UNCTAD. (1997). *Review of Maritime Transport*. Retrieved from Geneva, Switzerland: https://unctad.org/en/Docs/rmt1997_en.pdf
UNCTAD. (2003). *Review of Maritime Transport*. Retrieved from Geneva, Switzerland: https://unctad.org/en/Docs/rmt2003_en.pdf
UNCTAD. (2004). *Review of Maritime Transport*. Retrieved from Geneva, Switzerland: https://unctad.org/en/Docs/rmt2004_en.pdf
UNCTAD. (2009). *Review of Maritime Transport*. Retrieved from Geneva, Switzerland: https://unctad.org/en/Docs/rmt2009_en.pdf
Van de Ven, D. J., & Fouquet, R. (2017). Historical energy price shocks and their changing effects on the economy. *Energy Economics, 62*, 204-216.
Veenstra, A. W., & De La Fosse, S. (2006). Contributions to maritime economics—Zenon S. Zannetos, the theory of oil tankship rates. *Maritime Policy & Management, 33*(1), 61-73. doi:10.1080/03088830500513444
Williams, J. B. (1938). *The theory of investment value* (Vol. 36): Harvard university press Cambridge, MA.

Yin, J., Wu, Y., & Lu, L. (2019). Assessment of investment decision in the dry bulk shipping market based on real options thinking and the shipping cycle perspective. *Maritime Policy & Management, 46*(3), 330-343.

APPENDIX 1. Vessel Types

The Vessel Types- Tanker

ULCC/ VLCC	Newbuilding	Single Hull/ 315-320K DWT							
	Second-hand	350K DWT.1975	300K DWT.10 y. o	310K DWT 5 y. o	300k dwt 15 y. o	250K DWT 10 y. o	250K DWT 1976	265K DWT 15 y. o	
Suezmax	Newbuilding	156-158K DWT							
	Second-hand	140K DWT.1976	160K DWT 5 Y.O.	150K DWT 10 y.o.	150K DWT 15 y.o.				

Aframax	Newbuilding	113- 115K DWT							
	Second-hand	85 K DWT.1975	105 K DWT 5 y.o.	86 DWT 10 y.o.	86 DWT 15 y.o.	95-97 K DWT 20 y.o.	105 K DWT 10 y.o.	95-97 K DWT 15 y.o.	
Panamax	Newbuilding	73-75 K DWT							
	Second-hand	60 K DWT. 1980	73K DWT 5 y.o.	70K DWT 10 y.o.	70K DWT 15 y.o.	65K DWT 20 y.o.			
Handysize	Newbuilding	47-51K DWT	37K DWT						
	Second-hand	30K DWT. 1974	40K DWT. 1980	37K DWT 5 y.o.	37K DWT 10 y.o.	40K DWT 5 y.o.	47K DWT 5 y.o.	45K DWT 10 y.o.	45K DWT 15 y.o.

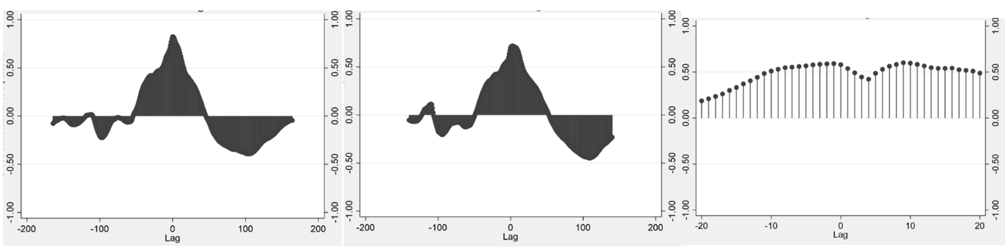
The Vessel Types-Dry Bulk

Capesize	Newbuilding	205-210K DWT	176-180K DWT	100-115K DWT				
	Second-hand	120K DWT. 1974	150K DWT 5 y.o.	180K DWT 5 y.o.	180K DWT 10 y.o.	170K DWT 15 y.o.	150K DWT 20 y.o.	
Panamax	Newbuilding	75-77K DWT	80-82K DWT	91-93K DWT				
	Second-hand	76K DWT 5 y.o.	75K DWT 10 y.o.	73 DWT 15 y.o.	69K DWT 20 y.o.	82K DWT 5 y.o.		
Handymax	Newbuilding	61-63K DWT						
	Second-hand	35K DWT. 1977	56K DWT 5 y.o.	35K DWT 10 y.o.	55-56K DWT 10 y.o.	56K DWT 3 y.o.	52K DWT 15 y.o.	42-45K DWT 20 y.o.

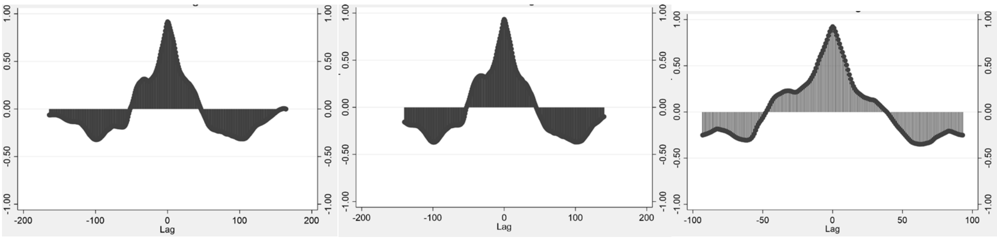
Handysize	Newbuilding	38-40K DWT	25-30K DWT					
	Second-hand	35K DWT 5 y.o.	27K DWT.1977	32 K DWT 10 y.o.	28K DWT 15 y.o.	27K DWT 20 y.o.		

APPENDIX 2. Monthly Cross-Correlation Results

<u>Monthly (Bulker) Cross-Correlation Results of SQ Indicator and TC Rate</u>



Handysize (5,10, 15 years old)



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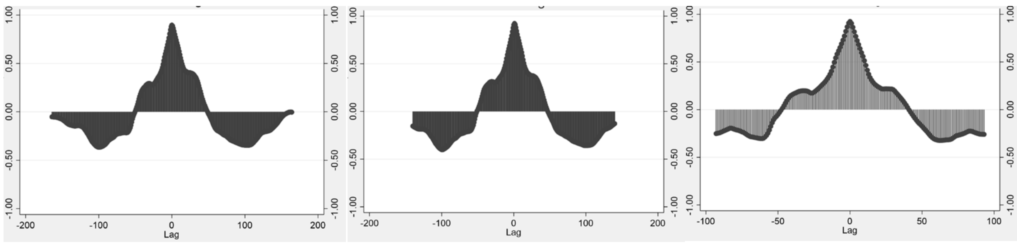
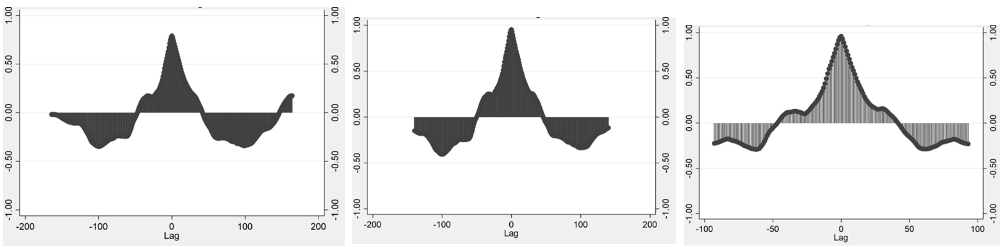
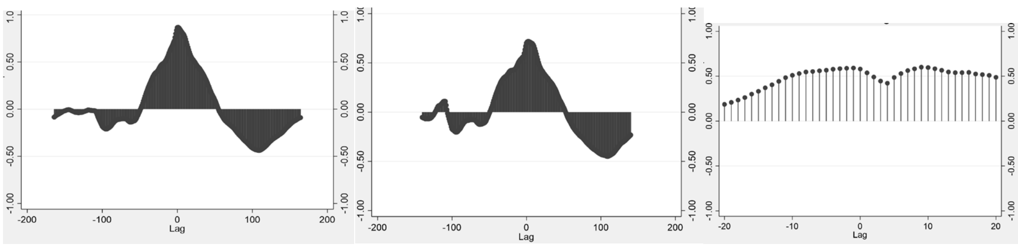


Panamax (5,10, 15 years old)

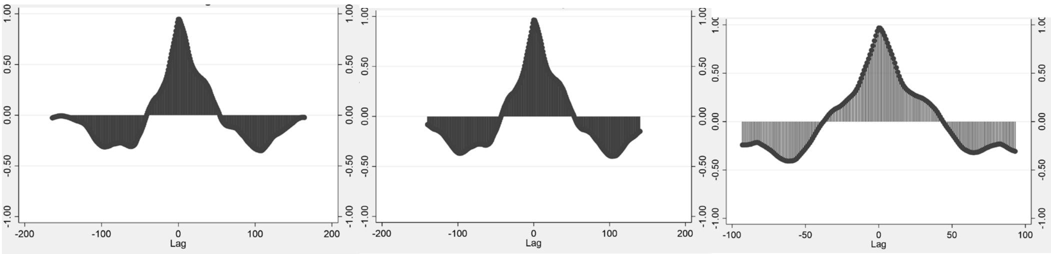


Capesize (5,10, 15 years old)

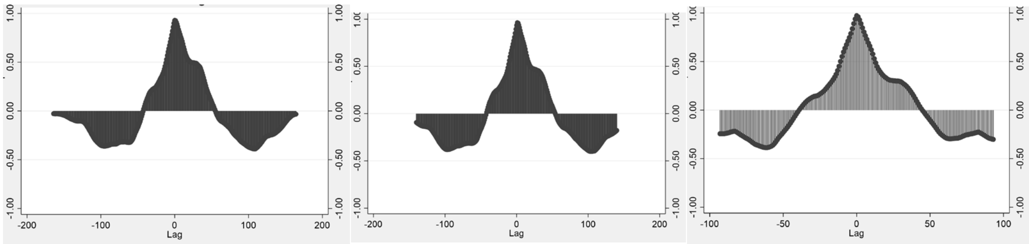
<u>Monthly (Bulker) Cross-Correlation Results of SQ Indicator and SH Prices</u>



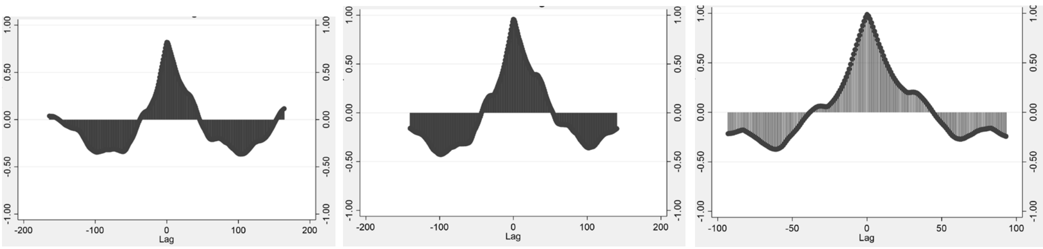
Handysize (5,10, 15 years old)



Handymax (5,10, 15 years old)

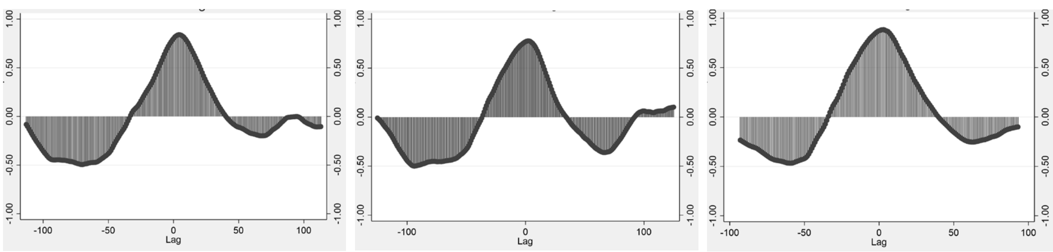


Panamax (5,10, 15 years old)

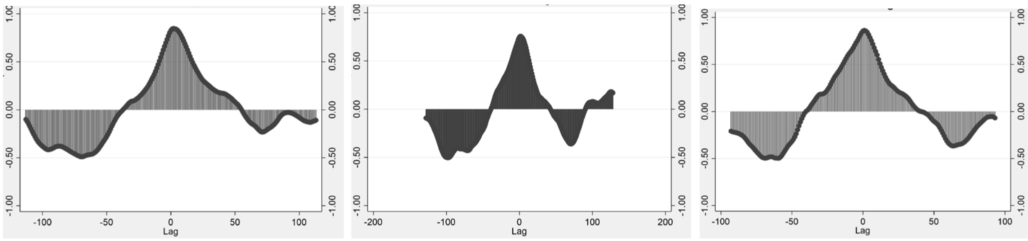


Capesize (5,10, 15 years old)

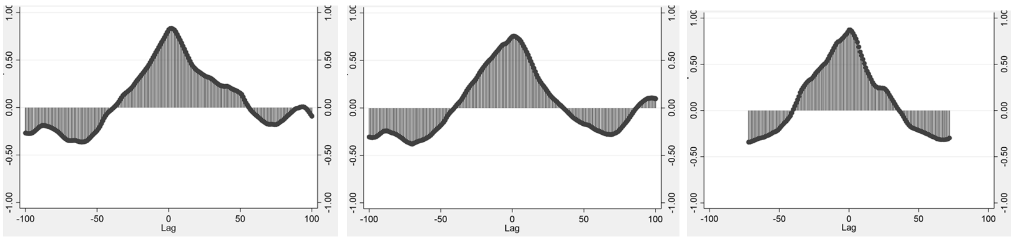
<u>Monthly (Tanker) Cross-Correlation Results of SQ Indicator and TC Rate</u>



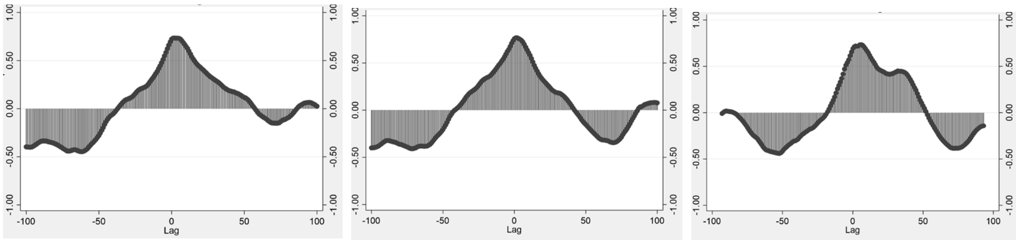
Product Tanker (5,10, 15 years old)



Aframax (5,10, 15 years old)

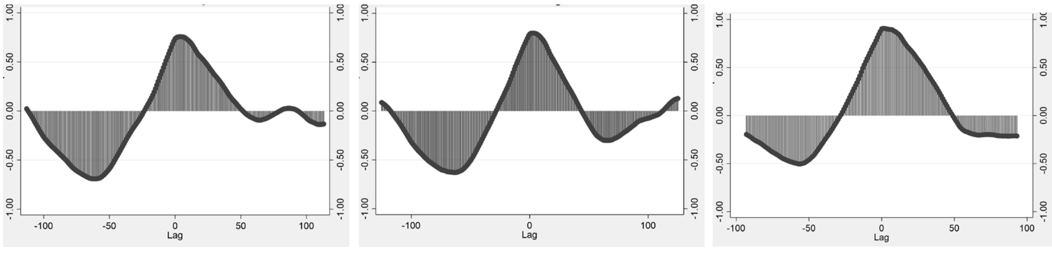


Suezmax (5,10, 15 years old)

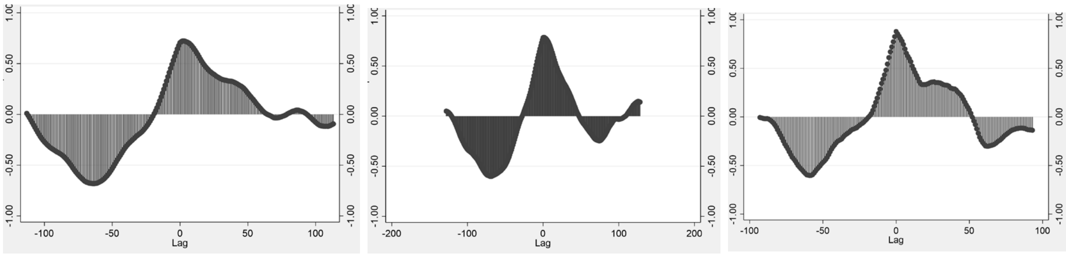


VLCC (5,10, 15 years old)

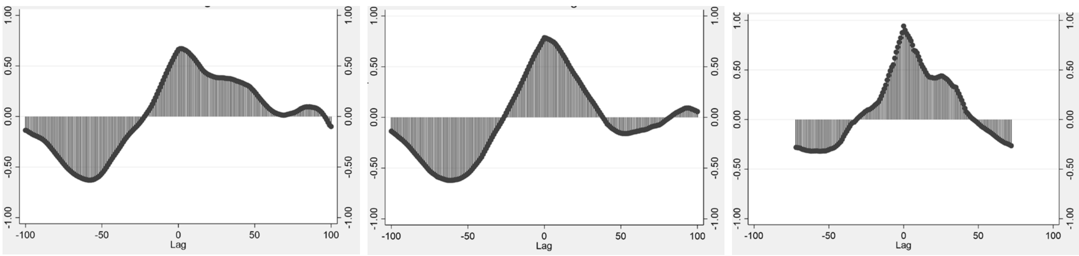
<u>Monthly (Tanker) Cross-Correlation Results of SQ Indicator and SH Price</u>



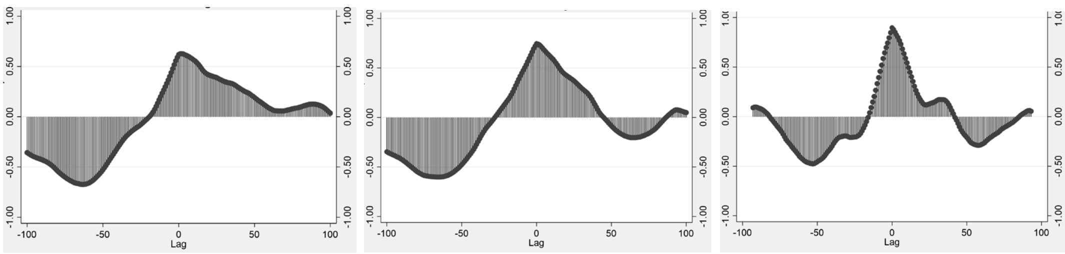
Product Tanker (5,10, 15 years old)



Aframax (5,10, 15 years old)



Suezmax (5,10, 15 years old)



VLCC (5,10, 15 years old)

APPENDIX 3. Published Papers

Paper 1: A Critical Review of the Literature on Firm-Level Theories on Ship Investment

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Abstract: The maritime industry is one of those rare industries that are both highly international integrated to international trade and also highly capital-intensive dependent on substantial investment amount. In the literature, ship investments have not been widely examined through the firm-level investment theories to explore the link between investment level and asset price valuation. The general trend in the literature of ship investments is to analyse the relationship among the shipping markets (newbuilding, second-hand, freight rate and scrap) and their impact on asset price valuation, the timing of investments and market entry and exit conditions. In this paper, we extensively reviewed the literature of firm-level investment theories and ship investments. We showed that the application of firm-level investment theories to the ship investments is confined to the basic investment valuation models, such as Net Present Value and Real Option Analysis. Ship investments need to be examined by firm-level investment theories to define firm/industry value maximization level within the approach of the solid investment theories.

Keywords: Investment Theories, Microeconomics, Ship Investments, Maritime Industry

1. Introduction

Business investments in the fixed capital have a crucial role in a nation's industrial and economic growth. Nowadays, the world average of the gross fixed capital formation corresponds to about 20 percent of Gross Domestic Product (GDP)[27]. Its contribution to the economy is not confined to the GDP. Investments facilitate the growth of factors of production both in physical and human capital stocks (Barro et al., 2004; Uzawa, 1965). Furthermore, the relationship between investment and factors of production is assumed to be bidirectional. As the firm continues to invest, the returns increase since new knowledge and technology are discovered (Arrow, 1962). The motivation behind the investment and therefore its contribution to the nation's economy is closely linked to the growth of international trade which gives the opportunity to maximize the wealth of a nation by discovering or opening up new markets. The fact that 90% of the world's trade is carried by sea puts the maritime industry in a critical role as a bridge to the markets of the international trade (UNCTAD, 2016). The link between maritime industry and the economy has been emphasized by researchers (Harlaftis & Kostelenos, 2012; Kang et al., 2016), and Cheng (1979) notes that the maritime transportation can be seen as a phase of production which is indispensable to economic progress.

The shipping industry as being a vital chain of economy and trade, the economic structure of the industry has also received increasing attention in the literature. The economics of shipping transport have been studied by various scholars (Buckley, 2008; Karakitsos et al., 2014; Metaxas, 1971; Stopford, 2009; Talley, 2011; Zannetos, 1966), and they have contributed to the literature by exploring the economics of shipping markets (newbuilding, second-hand, freight and scrap markets), freight fluctuations and the interrelationship between the markets. Mostly, ship investments have been studied through the market analysis perspective rather than through the application of firm-level investment theories. While there are numerous sources on the macroeconomics of the maritime industry, on the microeconomic level and in particular, on the firm-level investment approach, the literature is very scarce. The empirical research to explain the investment decision in the new or second-hand ships by existing ship owners or new entrants is rare and sporadic. From that perspective, there is an empty field in the literature to be filled regarding the interpretation of investors' decision on ships whether new or second-hand and ship price valuation in the market with the application of firm-level investment theories. Ship investments in the literature started receiving increasing attention by researchers from 1950s as a consequence of data availability and the role of shipping during globalisation. This inference brings the question which as to why the shipping industry has been absent from mainstream research in economics and economic history, despite having a very long and fascinating contribution in the world history (Paine, 2014). The absence of shipping industry from mainstream research is vividly noted by Harlaftis, Tenold, et al. (2012) that note that it is common to neglect the service sector in economic and historical research. Studies of the emergence of modern economic growth in industrialized economies usually focus on manufacturing, while seldom

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[27] The World Bank website visited online at 09/10/17, https://data.worldbank.org/indicator/NE.GDI.FTOT.ZS

emphasizing the importance of the service sector activities. Also, the maritime industry has been absent from mainstream research due to its inherent international character, which blurs the links to individual economies. The product of shipping, sea transport, takes place beyond national boundaries, and its income is earned abroad, removed from the economic structures of a specific country. It is indicative that economists analyzing national economies have classified shipping income as 'invisible earnings'. The third reason for the invisibility of the business of shipping is that it is 'intangible', and its absence from the core of economic analysis mirrors the situation of many other service industries. Finally, even the participants in the industry would like to remain "invisible". Indeed, some of the most prominent ship owners created elaborate organizational structures with the aim to obscure questions of asset ownership and strategies.

In the literature, there are five mainstream firm-level investment theories: accelerator, expected profit, liquidity, neoclassical and Q theory of investment, which apply to the shipping industry. The firm-level investment theories seem to have stagnated after the last quarter of 20th century[28]. In particular, investment theories between the 1900s and 1970s have taken a substantial role in the literature and showed significant progress. However, after the 1970s, the development of new investment theories has slowed down, and most of the subsequent studies dealt with the introduction of a new approach to existing theories, rather than suggesting a different theoretical approach. Some economists, such as Chang (2014) and McCloskey (2002; 2006), argue that the innovative growth process of economic thought slowed down in the 21st century.

The review of the five major firm-level investment theories, provided in the following section, highlights that most of the investment theories deal with determinants of investments under the assumptions of either instantaneous adjustment or distributed lag structure which is not related to any optimization process. The Q model seems to be the only exception which contains a theoretical foundation to allow a study of investment determinants by the principles of the economic relationships.

This paper provides a critical review of the five main firm-level investment theories and the literature on ship investments. Notably, the literature on ship investments has focused on the review of the ship investment decision making with a particular focus on the choice between new and second-hand ships and ship price valuation. The primary aim of this paper is to find a research gap and to justify a new type of method to be used to assess ship investment. Considering the aim of this paper, the main features of the five-mainstream firm-level investment theories and the ship investment literature are reviewed to discuss the applicability of the firm-level investment theories in the shipping

[28] Besides five major firm level investment theories, time series investment model derived by Kopcke [19] where the model considers the trends and cycles evident in recent experience which are sufficiently stable to describe the course of the investment in the future. The model is formulated by as $I_t = \sum_{i=1}^{n} a_i I_{t-1} + \sum_{i=0}^{n} b_i Q_{t-1}$, I is investment, Q is output. However, the model has not been widely applied by other scholars.

investment decision process. Based on the aim of this paper, following research questions to be answered in this paper:

1. What are the central assumptions of firm-level investment theories that can affect the application in the shipping industry?

2. Which are the most commonly used methods to research ship investments in the bulk and container shipping?

The rest of the paper is organized as follows. Section 2 introduces the ownership structure in the container and bulk shipping markets and provides an overview of ship investment in the world. Section 3 presents the theoretical approach of the five main firm-level investment theories over the period of the 1910s to 1980s. Section 4 elaborates the empirical studies in ship investments under two main categories, Bulk Shipping and Container Shipping after a systematic review of the literature from the 1960s until now. Finally, Section 5 reviews the gap in the literature and provide suggestions for the future research.

2. Overview of Ship Investments

The bulk and container shipping markets show a different pattern of ownership and therefore investors. The ownership in the container market in terms of container ship capacity includes owned ships by the liner companies and chartered in tonnage from independent ship managers not engaged in the provision of liner services (UNCTAD, 2017). The market structure in liner shipping resembles an oligopolistic market structure. Moreover, after the recent mega container-shipping mergers and acquisitions, the degree of market concentration has increased. UNCTAD (2017) reported that as of January 2017, the top 17 carriers collectively controlled 81.2 percent of the global liner capacity, while a year earlier the 20 leading carriers-controlled 83.7 percent of the global liner capacity.

In the bulk shipping markets, and particularly the tanker market, the ownership structure has significantly changed after the 1950s. While oil companies in the 1950s controlled the majority of tanker ships, in 2000s, the majority of the tanker fleet is controlled by independent owners and a significant percentage of the fleet operates in the spot market (Glen et al., 2002; Veenstra et al., 2006). In the dry bulk market, following the dispersion of state-owned fleets after the collapse of the former Soviet bloc, independent ownership has increased, and the spot charter market has always been a significant percentage.

In the literature, there are some studies on containership investments (Fan et al., 2013; Fan et al., 2015; Luo et al., 2009) from either firm level or industry level perspective due to firm-level data availability for container shipping companies. However, the studies in bulk shipping are confronted with low availability of firm-level data. Therefore, industry-level data is mostly used in studies on the bulk shipping (Alizadeh et al., 2007; Merikas et al., 2008; Tsolakis et al., 2003). Depending on data availability, firm-level investment theories can be applied on industry level in bulk shipping and on firm and industry level in container shipping.

In the context of ship supply growth, in long-term, the shipping industry receives the increasing attention from investors along with the growing world trade. However, it shows a highly volatile trend in the short run due to the effect of external economic shocks and regional disputes. According to UNCTAD (2017), the order book of the dry bulk sector has reached a peak level and increased from 75 million dead-weight tons (dwt) in 2007 to 322 million dwt in 2011. Similar peak levels are recorded in the oil tanker sector during 2006 and 2009 with an increase from 97 million dwt to 192 million dwt. The bulk shipping, both dry and wet bulk, have witnessed a sharp decrease as a consequence of the Global Financial Crisis, 2008 (GFC). On the other hand, the order book of container shipping has been less affected from GFC and reached a peak level of 79 million dwt, in 2008. In 2016, the order book of container ships reached 43 million dwt. In addition, to the slowdown in the order book, demolition activities have increased recently. In 2016, the shipbuilding activity contracted by 1.7 percent, while ship scrapping increased by 25.7 percent (UNCTAD, 2017). The recovery process in the ship investments has not shown a substantial increase after GFC which is, in fact, an expected outcome since global economic growth is still in the recovery process. The World Economic Outlook Report of IMF (2015) reported that the global growth rate is still far below the expectations and the recovery has not been completed yet. While the global economic activities showed an upswing move in 2017 and there are definite expectations for 2018, growth remains weak in many countries, and inflation is below target in most advanced economies.

3. Firm-Level Investment Theories

The fundamentals of the firm-level investment theory go back to Keynes (1936) and Fisher (1930). They both argued that investments are made until the present value of expected future revenues is equal to the opportunity cost of capital. Fisher (1930) primarily conceptualized the central concept of neoclassical investment theory which is the maximization of the present value of the firm, introduced the equation of net present value (NPV) in the book of "*The Rate of Interest*". The investment is expected to produce future cash flows, $C(t)$and the net present value can then be written as:

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_0, \quad (2.1)$$

Where, C_t is net cash inflow during the period t, C_0 is total initial investment costs and r is the opportunity cost of capital (discount rate).

As long as the expected return on investment, abbreviated as i, is above the opportunity cost of capital (discount rate), r, then the investment will be worthwhile. In case of the cost of opportunity cost is equal to the expected return on investment, then NPV will be equal to zero. The expected return on investment, i, is equivalent to Keynes' marginal efficiency of capital and Fisher's internal rate of return.

Net Present Value (NPV) and Discounted Cash Flow (DCF) are well known and widely applied analyzing tools in investment decision-making process of the firms. A project can be accepted when the value of the NPV is greater than or equal to 0. However, the DCF is a static tool of analysis and ignores future uncertainty likely to occur that can negatively affect future cash flows. This implies that the DCF analysis does not comply with real-world dynamic interactions and the highly risky and uncertain investment environment of the shipping industry asks to consider an alternative method to evaluate investment alternatives.

As an alternative to the static DCF method, the dynamic Real Option Analysis (ROA) method was introduced by Dixit et al. (1994a) and is widely applied in the shipping industry (Bendall et al., 2005; Bendall et al., 2007b; Dikos, 2008; Dikos et al., 2003; Dixit et al., 1994b; Gkochari, 2015; Hopp et al., 2004). The ROA is treated as an alternative method to manage capital budgeting process under uncertainty and irreversibility with additional options which can be exchanged with low-risk income streams associated with one strategy with that of another strategy (Bendall et al., 2007a). More recently, Balliauw (2017) applied ROA in container shipping to analyze the performance in the shipping markets of a theoretically developed model to market entry and exit decision of ship owners. The author found that the theoretical model, ROA, conforms to the real market values when the market is steady. However, in case of fluctuations of in sale and purchase prices, then the model needs to be realigned by new market values.

Following the basics of investment evaluation tools, we will now focus on the accelerator theory which is the oldest of the firm-level investment theories. This will be followed by the profit theory, the liquidity theory, the neoclassical theory and the Q theory.

3.1. Accelerator Theory

The simple accelerator theory was introduced by Clark (1917) and in the simple accelerator model, the actual capital stock K_t adjusts instantaneously to the desired capital stock, which is formulated as $K_t = K_t^*$. Refer to principles of accelerator theory of investment behavior; the desired capital is proportional to the output which is constant, μ:

$$K_t^* = \mu Y_t \qquad (2.2)$$

The equation follows that net investment, I_{nt} which is the increase in the actual capital stock can be specified as:

$$I_{nt} = K_t - K_{t-1} = K_t^* - K_{t-1}^* = \mu(Y_t - Y_{t-1}) \qquad (2.3)$$

Equation (2.3) demonstrates the link between investment and changes in output, which expresses that change in output might lead to an accelerated change in investment. The model assumes that a complete and instantaneous adjustment of the capital stock. As being the earliest model, the accelerator theory was exposed to many criticisms by scholars (Chenery, 1952; Koyck, 1954; Tinbergen, 1938) who developed the flexible accelerator model. The first criticism was that the model was restricted by the unrealistic assumption of instantaneous adjustment of the capital stock. The second, as econometric results show that the estimated value of the parameter μ is much smaller than the observed ratio of capital stock to output. The third criticism was that in the simple accelerator model, the prices of capital equipment, wages, taxes and interest rates were ignored (Baddeley, 2002). In response to the drawbacks of accelerator model, the flexible accelerator model was formulated by Goodwin (1948) and Chenery (1952). In particular, Chenery (1952) added reaction lags in the capital stock. These lags show the time gap between changes in demand and new investment activity. These lags are able to capture the delays between the investment decision and the investment expenditures. The actual level of capital in period t was denoted by K_t and the desired level by K_t^*, capital is adjusted toward its desired level by a certain proportion of the discrepancy between desired and actual capital in each period, which is formulated as follows:

$$K_t - K_{t-1} = \lambda(K_t^* - K_{t-1}) \qquad (2.4)$$

Where 0< λ<1 is a parameter, this equation is from Koyck (1954) distribution lag function.

To obtain investment function, investment variable inserted into the equation (2.4) which states that changes in the stock capital level equal gross investment less depreciation:

$$I_t = \lambda(K_t^* - K_{t-1}) + \delta K_{t-1} \qquad (2.5)$$

Where I_t is gross investment, and δ is the depreciation rate.

The main difference between simple accelerator model and flexible accelerator model is flexible accelerator includes in lags in capital stock which avoids the unrealistic assumption of instantaneous adjustment of the capital stock and corresponds to the dynamic structure of investment.

3.2. Expected Profit Theory

The expected profit theory emerged as a subsidiary hypothesis under the accelerator theory (Tsiang, 1951). Significant contributions to profit theory were made by Tinbergen (1939), Kalecki (1949), Klein (1951) and Grunfeld (1960). The expected profit model was developed based on the approach is that the investment decisions are made by considering the present value of expected future profits (Kuh, 1963). Tinbergen (1939) has clarified the concept of profit theory as: "*There is fairly good evidence that the fluctuations in investment activity are in the main determined by the fluctuations in profits earned in the industry as a whole some months earlier*" (Tinbergen, 1939, p. 49). However, the expected profit model was later criticized by Grunfeld (1960) by adding the current profit into the flexible accelerator model and found that the partial correlation between profits and investment was insignificant. In the aftermath, the author states that the results did not confirm that profits are a good measure of expected profits or that they tend to lead investment expenditures. He added that; "*The observed simple correlation between investment and profits seems to be due to the fact that profits are just another* *measure of the capital stock of the firm and one that is in most cases inferior to the measure that we have constructed."* (Grunfeld, 1960, p. 219). In Grunfeld (1960)'s theory, desired capital is proportional to the market value of the firm in the securities market.

$$K_t^* = \alpha_1 + \alpha_2 V_t, \quad (2.6)$$

Where V_t is the firm's market value, α_1 and α_2 are parameters. Combining (2.5) into the distribution lag function (2.4), then following equation produced:

$$I_t = \beta_1 + \beta_2 V_t + \beta_3 K_{t-1}, \quad (2.7)$$

The expected profit model has some advantages and disadvantages to apply in business models. The main advantages of the theory is that which recognises the role of expected profit in the investment decision. Besides, the market value of the firm was measured as the market value of stocks outstanding plus the book value of debt including short-term liabilities. The expected profit theory is the first model used the market value of the firm in analysing the investment behaviour which inspired to create Q theory.

3.3. Cash Flow/Liquidity Theory

The liquidity theory was developed as an alternative to the criticism of the accelerator investment theory and the expected profit model. The theory was proposed by Meyer et al. (1957), Anderson (1964), Kuh (1963), Meyer et al. (1964) and Duesenberry (1958). The main argument of the liquidity theory is that cash flow dominates the level of investment and when internal funds are exhausted, the schedule of the supply funds rises sharply to keep the capital level at the desired point (Jorgenson et al., 1968). In the liquidity theory of investment behaviour, desired capital is proportional to liquidity,

$$K_t^* = \alpha L_t, \quad (2.8)$$

where α is the desired ratio of capital to the flow of internal funds available for investment.

In order to obtain the investment function, V_t in equation (2.7), expected profit model, can be replaced by FC_t, then produced equation (2.9):

$$I_t = \beta_1 + \beta_2 FC_t + \beta_3 K_{t-1}, \quad (2.9)$$

The cash flow-liquidity model reflects both the firm's internal funds and the profit levels (Kuh, 1963). Therefore, it is not an alternative to the expected profit model. Rather it might be seen as augmenting the expected profit model by incorporating the cost of investment funds. However, the main drawbacks of the liquidity model are related to constraints not taken under consideration such as transaction costs in the financial markets and the fact that factors such as the interest rates and the prices of equipment and machinery are ignored.

3.4. Neoclassical Theory

The neoclassical theory of investment theory is based on optimal capital accumulation (Jorgenson et al., 1968) which is extensively studied by Jorgenson (1963; 1967; 1971). The investment theory is founded on the assumption that capital accumulation is based on the objective of maximising the utility of a stream of consumption. The main principle of the theory of optimal capital accumulation meets the basic objective when: "*The firm maximizes the utility of a consumption stream subject to a production function relating the flow of output to flows of labour and capital services*." as Jorgenson (1967, p. 136) stated. The net investment is equal to total investment less replacement. There is a connection between the capital stock K(t) and the rate of investment I(t) which takes the form as:

$$\dot{K}(t) = I(t) - \delta K(t), \quad (2.10)$$

The equation (2.10) states that the rate of change of the capital stock, $\dot{K}(t)$, is equal to the purchase of new capital, $I(t)$, less the amount of capital depreciation, $\delta K(t)$. The investment function with lag distribution suggested by Jorgenson (1963; 1967), given in equation (2.11):

$$I_t = w_0(K_t^* - K_{t-1}^*) + w_1(K_{t-1}^* - K_{t-2}^*) - \alpha_1(I_{t-1} - \delta K_{t-2}) + \delta K_{t-1}, \quad (2.11)$$

Compared to previous models, the neoclassical model has some advantages. First, the net worth maximisation model defines the link between investment and expected profits of firms. Second, the neoclassical theory of investment primarily identified the user cost of capital, which was not considered in previous models. Also, the user cost of capital concepts has inspired the Q model to include adjustment cost function. Lastly, the neoclassical model consists of many other variables such as tax, interest rate, output level; therefore, it is easier to measure their impact on investment. On the other hand, the model is subject to criticisms. First, output has still a substantial effect as a determinant of investment, compared to the user cost of capital which has a modest effect on investment function (Chirinko, 1993). Second, the investment decision process is considered as dynamic instead of being static (Kuh, 1963), and the Jorgenson (1971) attempted to modify the neoclassical model subject to dynamic optimisation. However, the first order conditions used to derive the optimal level of capital stock stayed static.

3.5. Tobin-Q Theory

The Q theory of investment has been developed by Brainard et al. (1968) and Tobin (1969; 1978), but the foundation of the model goes back Keynes (1936), he stated that: "*Daily revaluations of the Stock Exchange inevitably exert a decisive influence on the rate of current investment. For there is no sense in building up a new enterprise at a cost greater than that at which a similar existing enterprise can be purchased; whilst there is an inducement to spend on a new project what may seem an extravagant sum, if it can be floated off on the Stock Exchange at an immediate profit.*" (Keynes, 1936, p. 151). The model proposed that investment expenditures are positively related to average Q, which has defined as the ratio of the financial value of the firm to the replacement cost of its existing capital stock (Chirinko, 1993).

In particular, Q model emerged to address two fundamental problems of neoclassical theory and accelerator theory of investment. The first problem was the capital adjustment process which was initially accepted as instantaneous and complete in each period, in the neoclassical model and Q model, the adjustment cost is described as a strictly convex function. The convex adjustment cost was initially proposed by Jorgenson (1963), Eisner et al. (1963), Lucas Jr (1967) and Gould (1968), which was incorporating the adjustment cost function into firm value maximisation function of the neoclassical model. The second problem was that the role of expectations in future investment opportunities was not evaluated by the previous studies and Brainard et al. (1968) and Tobin (1969) worked on this problem. They suggested that investment is made until the market value of assets is equal to the replacement cost of assets (Eklund, 2010). Then the investment equation (2.6) introduced as below:

$$\left(\frac{I}{K}\right)_t = \beta[Q_t - 1] + u_t, \tag{2.12}$$

where $\beta = 1/\alpha$, u_t is an error term, and Q is called "*marginal Q*", which equals the ratio of the shadow price to the replacement unit cost of capital. The Q value captures the effect of an additional dollar of capital on present value of profits, therefore, the firm decides to increase the capital stock if Q is high and reduce the capital stock if Q is low (Romer, 2006).

The marginal Q variable is unobservable, and therefore its data is not available. To solve it, Tobin (1969) replaces the marginal Q variable with the average Q, which is the ratio of the firm's market value to its replacement cost. Use of average Q in place of marginal Q, since investment regression is likely to suffer from misspecification. Hayashi (1982) worked on this problem and stated that marginal Q and average Q is identically equal, $q_m = Q_a = 1$, if the firm is a price taker (perfect competition), and their production and installation functions are linear homogeneous. If this condition is violated, then investment equation is likely to be biased.

Application of Q model to various industries has risen a question as to how to calculate Q variable in practice. There are some different calculation methods offered by various scholars based on the specific research field where Q ratio has been used. Peters et al. (2017) worked on intangible capital and investment and computed the Q variable as the ratio of the total investment includes the investment in physical and intangible capital to the total capital stock includes physical and intangible capital stocks. Furthermore, Hall (2001) defined the Q variable as the ratio of the value of ownership claims on the firm, less the book value of inventories, to the replacement cost of equipment and structure.

The role of Q theory was widely questioned by scholars, and its explanatory power in investment relation was accepted poor (Bond et al., 2007; Caballero et al., 1995). However, more recently Kilponen et al. (2016) studied on the Q theory of investment by the frequency domain on the US data of corporate fixed private non-residential investment in equipment and structures from 1972 to 2007. They reinterpreted Q theory based on Rua (2011) study, a wavelet approach to forecasting. In contrast to the literature, they found that Q model might be better explaining short-term relations rather than long-term ones by considering frequency relationship between Q and investment. Moreover, they found that using the wavelet approach and the proxies for Q significantly increases the predictive power of the investment equation. In some research, extended Q model of investment decision is integrated into dynamic risk management analysis with financial tools. These showed that for the firm's investment opportunities and when there are no fixed costs of investment the marginal Q is a more accurate measure than average Q (Bolton et al., 2011). Moreover, Q ratio, itself, applied to measure the performance of the airline industry (Li et al., 2004) and proved that Q ratio captures additional dimensions of the airline performances compared to other financial measures. More recently, Skjeggedal (2012) applied Q theory into Norwegian housing from 1992 to 2011, where the value of Norwegian housing, Q, is defined as the ratio of housing prices to the construction costs of new housing and housing is defined as the aggregate housing stock in Norway's national accounts. The author stated that the value of housing is significantly related to housing investment according to the Q theory model of housing.

4. Empirical Research in Ship Investments

The shipping industry is usually categorised under four markets: the newbuilding market, the freight market, the sale and purchase market, and the demolition market (Stopford, 2009) and each market is further broken down according to the principal vessel types: Dry and Wet Bulk, Container, General Cargo and others. The literature on ship investments has mostly examined two primary markets, newbuilding and second-hand markets, which are very intensive and active investment markets (Tsolakis et al., 2003); and their interactions with freight markets. In this paper, the empirical studies on ship investments have been reviewed within this perspective (newbuilding, second-hand and freight markets relationship) and they are mainly grouped under two main sectors: Bulk and Container Shipping Markets.

4.1. Bulk Shipping Market

Dry Bulk Shipping Market

The recent empirical studies in the bulk or container sectors mostly focused on specific vessel types; they tend to avoid generalising the research outcomes on the vessels types since they have structural differences. However, some early researchers examined country level investments for all vessel types, except some well-known studies, such as Zannetos (1966) that worked on tankers and Metaxas (1971) that worked on the economics of tramp shipping. On the other hand, Marlow (1991c) had an empirical study followed by the research series (Marlow, 1991a; 1991b) to analyse the maritime industry regarding the relationship between industry incentives and investment levels for UK shipping industry. In the research series, besides providing strong theoretical background for the shipping industry incentives and investment level, the empirical model has been tested by a number of modified variables to obtain the best output. The model did not produce the expected outcome of a positive link between incentives and investment levels. This unexpected result may be due to running the analysis for all type of vessels which is likely to lead bias in the sample, and further data collection might be required to determine precisely how incentives affect investment levels.

The studies after the 1990s are more likely to analyse specific vessel types, for example, Dikos et al. (2003) analysed the second-hand ship valuation by using newbuilding prices and charter rates on dry bulk shipping market over the period of 1976 and 2002. They developed the model based on the real options approach to analyse shipping investment decision and applied structural partial equilibrium framework to examine the prices of second-hand vessels through the prices of new vessels and the charter rates. The empirical results show that the hidden asset play value in the prices of second-hand vessels had been empirically proven within the developed model. In line with Dikos et al. (2003), the study of Tsolakis et al. (2003) examined the second-hand ship prices for the tanker and dry bulk markets from 1960 to 2001. They analysed the price valuation by Error Correction Model. The model consists of comparatively comprehensive variables, such as the newbuilding price, the interest rates and time charter rate. Their main finding is that second-hand prices in different types of ships react differently to the underlying fundamental factors. They indicate that newbuilding prices have a higher effect on the determination of second-hand prices than time charter rate.

Both Dikos et al. (2003) and Tsolakis et al. (2003) applied modern finance theories and advanced econometric methods: Real Option approach and Error Correction Model respectively. Analysing the different shipping markets through financial theories and advanced econometric models contributed twofold to the literature: first, interpreting the industry with modern financial tools provided an insight to understand the second-hand ship valuation with a financial approach, second, advanced econometric tools eliminated previous statistical drawbacks such as multicollinearity and heteroscedasticity problems. Moreover, these two papers inspired many future researchers to develop their model based on advanced financial approaches and applying advanced econometric tools.

Furthermore, with the right timing of investment, the return can increase. Especially, in the shipping industry as a highly capital-intensive industry, timing is a key concept to increase return and control the risk. Alizadeh et al. (2007) used the price-earnings ratio to investigate investment decision in the sale and purchase market for dry bulk ships over the period of 1976 to 2004. They proposed a co-integration approach for timing investment and divestment decisions in shipping markets. The proposed model, second-hand ship price-earnings (P/E) ratio, was developed as a substitute approach to the usage of Efficient Market Hypothesis in the shipping industry. Their findings supported that the relationship between second-hand ship price and earnings may guide about the future behaviour of ship price, which can be used for investment timing in shipping markets. Furthermore, this study has a guidance role to advice market participant with an alternative investment decision tool; the price-earnings ratio that reflects the relative degree of over or undervaluation in asset prices. Gkochari (2015) had also recently studied the investment timing in dry bulk shipping market by applying the combined methods of option pricing (Real Option Analysis) and game theory, called the combination as option games approach which has been initially introduced in this paper. The extended model can be accepted as an adaption of Real Option Analysis (Dixit et al., 1994a) into dry bulk shipping market. The extended model contributed to the understanding of boom-and-bust cycles in shipping industry which is mainly caused by construction cascades, and recession-induced construction booms are the time-to-build delay. Lastly, the author used the log P/E ratio to test its role in informing investors for future of the market. She found that the log P/E holds guiding characteristic during market fluctuations and the movement of this ratio can be accepted as a signal for the new investment decision.

Kalouptsidi (2014) had a study to explore the nature of fluctuations of demand for sea transport and the effect of time to build on the level and volatility of the investment. She applied extensive theoretical and econometric tools used to explain the fluctuations on demand for bulk transport and time to build effect on investment through second-hand ship sale transactions, shipping voyage contracts, newbuilding transactions and demolitions from 1998 to 2010. The model proposed in this study lied within the general class of dynamic games in Ericson et al. (1995) and is closest to the model of entry and exit in Pakes et al. (2007). Their findings showed that the investment volatility is significantly higher as the time to build declines; on the other hand, prices are less volatile as the time to build declines. In line with Alizadeh et al. (2007) and Kalouptsidi (2014), Greenwood et al. (2015) studied the investment cyclicality of the shipping industry considering the investment boom and bust cycles and returns on capital in the dry bulk shipping industry. They proposed and estimated a behavioural model of industry cycles. In the model, firms over extrapolate exogenous demand shocks and partially neglect the endogenous investment response of their competitors. They found that firms overinvest during booms and are disappointed by the subsequent low returns.

Dai et al. (2015) analysed volatility spillovers effects across the newbuilding and second-hand vessel markets and freight market of dry bulk shipping by applying a tri-variate GARCH model over the period of 2001 and 2012. Although the study is not directly considering ship investments, it has developed a robust argument on newbuilding and second-hand ship price fluctuations and their relationship with freight rate. Therefore, the study has some distinctive contribution to the literature, since it has mainly examined the relationship among the freight rate volatility, newbuilding and second-hand vessel price volatility which has been widely ignored in the mainstream of research. Their results provided some valuable contributions regarding second-hand, newbuilding and freight markets. First, they found the volatility spillovers effect from second-hand market to freight market is dominant and, the direction of the volatility is from the newbuilding to the second-hand market gets stronger. Second, they found unidirectional transmission effect between freight market and newbuilding market as volatility transferred from freight market to newbuilding market, but not vice versa. Their findings are partially against the conventional assumption in the shipping industry which is believed that the demand drives the supply. Some critiques can be made about the empirical analysis that runs between 2001 and 2012. During the given time frame, the bulk shipping industry had peak level in vessel prices both in newbuilding and second-hand market and had peak level in freight rates; and right after 2008 Global Financial Crisis (GFC), had a very sharp decrease in all the markets and the economy (Celik Girgin et al., 2017). This might have led to have empirical outputs against conventional approach in the shipping industry since GFC had distorted the market and the freight rate could not reflect the real demand status, or even, in turn, the freight rate volatility could be determined by the instant second-hand vessel transaction price volatility.

Moreover, Dai et al. (2015) examined additional model to advise ship owners for the time-varying vessel prices. The model introduced the investment ratio, which is a function of conditional variances to covariances of newbuilding and second-hand price volatilities for each period. Therefore, the ship owners and investors can optimise their portfolio management regarding the time-varying vessel prices.

More recently, Papapostolou et al. (2017) investigated the effect of intentional and unintentional herd behaviour in the dry bulk market in the process of newbuilding investment decision and scrapping existing fleet. The herd behaviour among bulk ship-owners was examined by the cross-sectional absolute deviation (CSAD), through asset-return and vessel price valuation methods widely applied by scholars; such as price-earnings (PE) ratio (Alizadeh et al., 2007) and second-hand- newbuilding price (SHNB) ratio (Merikas et al., 2008). They detected unintentional herding behaviour while deciding to have newbuilding and scrapping existing vessel.

Tanker Shipping Market

An early example of research into the tanker market goes back to Zannetos (1966). He analysed the tanker transport and provided the fundamentals of the economics of tanker transport for future researchers. He had a significant contribution to the literature regarding the competitive markets and ownership patterns, economies of scale, the relationship between freight rates and oil prices, capital mobility, and elastic expectations. The study is still useful with a theoretical approach, although its empirical part became obsolete (Veenstra et al., 2006).

After the 1990s, the tanker market has been examined by most advanced econometric techniques. Kavussanos (1996) analysed the second-hand tanker market with price volatility and time-varying risk. Time-varying price fluctuations for three main ship sizes are examined by extended ARCH model. The paper influenced by Markowitz (1952)'s Modern Portfolio Selection Theory, described the portfolio selection process by the ship-owners as profit-maximising agents which have a portfolio of shipping assets, the risk is defined by the return which will be obtained through a different type of assets. The findings are empirically explained the high market fluctuations during and right after periods of significant imbalances, such as the oil crisis in 1980 and Iran-Iraq War in 1979.

Also, the paper explicitly showed the role of oil prices in price changes and eventually, it affects the behaviour of investors in the industry. Specifically, it indicated that oil prices and second-hand tanker prices changes have a negative relationship and at the same time, oil prices and volatilities of tanker price changes have a positive relationship. Three types of vessel are highly exposed to external shocks with the larger vessels being more risk-prone. Therefore the price of larger vessels is more volatile than smaller ones for the given period (1980-1993). The research directly advices the investors by stating riskier vessel for the given time frame and defined sample.

More recently, Alizadeh et al. (2006) analysed buy and sell trading strategies for the tanker vessel based on their size. This study is preliminary work of Alizadeh et al. (2007). In both studies, the earnings-price ratio was used to investigate investment decision in the sale and purchase market. Their findings indicated that the relationship between price and earnings in shipping markets contains essential information about the future behaviour of ship prices. The volatility in prices of larger tankers is higher than in smaller ones which provides an excellent opportunity for asset players.

Merikas et al. (2008) had seminal study in tanker carrier; they introduced a variable of the ratio of second-hand price over the newbuilding price (SH/NB) as a useful decision-making tool in the tanker market. They used SH/NP ratio as a dependent variable to analyse the relationship between the main shipping markets and to compare this relationship within the different type of vessels in the tanker industry. They analysed the cointegration relationship between the ratio of SH/NP with freight rate, international trade, shipbuilding cost, market risk (freight rate volatility), crude oil price, and interest rate through the Error Correction Model. They found that in a booming freight market, a ship-owner needs to purchase a modern second-hand vessel to capitalise on the strong freight market. When the freight market drops, the ship-owner should order new vessels, due to the optimism regarding the recovery of the market in the future.

4.2 Container Shipping Market

The consequence of the booming process of containerization over the period of 1970-80s (Broeze, 2002), the investment in container shipping has considerably increased. The order book for container ships increased from 11.922 to 43.259 thousand dwt from 2000 to 2016 (UNCTAD, 2016). Along with the increase in investment, container shipping market has recently received increasing attention from scholars. The study of Luo et al. (2009) analysed the container freight rate fluctuation attributable to the interactions of demand for container transportation services and the container fleet capacity. They empirically evaluated demand increase and fleet capacity increase which will lead to freight rate increase. Besides, the authors focused on the future freight rates after the 2008 Global Financial Crisis (GFC). They generated a forecasting model where freight rates fluctuate due to the impact of decreasing demand in the international trade. The freight rate is expected to decrease as demand decreased sharply after the crisis. In the post GFC period of, newbuilding orders were cancelled, which leads a supply to decrease. They predicted the future response of the freight market as a circular movement whereby after the cancellation of newbuilding orders freight rate decrease is restrained by a certain amount. The expectation is that by the cyclical effect the freight rate will slowly increase.

The ship capacity expansion and ship choice decision in containers have been studied by Fan et al. (2013). They extensively outlined the container market and provided a binary choice model to examine the capacity expansion decisions and nested logit models to examine ship selection decisions. They found that investors are keen to invest when demand and charter rates are high. They provided some valuable insight into investment behaviour of the companies listed in top 20, where they invest to keep their market share at a stable level, while the rest invest aggressively in obtaining high growth. Furthermore, they found that ship companies initially decide whether to order a new ship or a second-hand ship instead of deciding ship size. Based on their empirical findings, new vessels are more favourable than second-hand ships in the container market, when time to build is short, and demand is low. When building time is long, and market demand is high, then second-hand ships become more favourable. Moreover, the dynamic relationship between newbuilding prices, time charter rates and second-hand ship prices in the container market has been investigated by Fan et al. (2015). They applied two different analysis methods to investigate the dynamic correlations among newbuilding prices, second-hand prices and freight rates in the container market; VAR cointegration model to test the long run correlation among the three variables and Bai-Perron test to analyse multiple structural changes in multiple linear models. Their results confirmed the existence of structural changes in the correlation between ship prices and freight rates. The authors also found that while freight rate is decreasing, the newbuilding price is more fluctuating than the time charter rate and the second-hand price. On the other hand, while freight rate is increasing, the time charter rate is more fluctuating; and in a matured stable situation, the second-hand prices get in increasing trend.

After reviewing the empirical papers on investments in maritime transport based on their vessel types, Figure 2.1 Literature Review Summary will provide a brief summary of the selected papers.

Table 1. Literature Review Summary.

	Scope and Approach	Dataset/Sample	Dependent Var. (Output)	Independent Var. (Input)	Key Findings	Study/Authors
1	Second-hand ship prices valuation analysis/Real Option Value Approach	Tanker and Dry Bulk/Entire world	Second-hand price of a vessel	New Vessel Expenses The ratio of time charter earnings and capital expenses (EBITDA/CAPEX) Time charter rate Depreciation	They provided substantial evidence for a time-varying market price of risk. In other words, the hidden asset play value in the prices of second-hand vessels has been empirically proven within the developed model.	Dikos and Marcus (2003)
2	Econometric analysis of second-hand ship prices/Error Correction Model	Tanker and Dry Bulk/Entire world	Second-hand price of a vessel	Time charter rate New Building Price Order book/Fleet Ratio LIBOR (cost of capital)	New building and time charter have a significant effect on all determinants of second-hand prices. The cost of capital was found insignificant in tanker, in bulk, it is significant and negative in long run	Tsolakis et al. (2003)
3	Analysing the role incentives on investment levels/Capacity Utilization Approach	UK Shipping Industry	Investment	Capacity utilisation Existing capital stock Change in output Investment incentives Credit arrangements Expectations (New orders)	Despite the expectation of the positive link between investments and government incentives, the output showed that there is a negative relationship.	Marlow (1991c)
4	Analysing the investment and divestment decisions/The Stationary Bootstrap Approach	Dry Bulk/Entire world	Investment/Divestment	Five years old Ship Prices Time charter rates Price/Earnings	Strategies based on earnings-price ratios out-perform buy and hold strategies in the second-hand market for ships. This is especially true in the market for larger vessels because of higher volatility in the larger size sections	Alizadeh and Nomikos (2007)
5	Analysing the impact of time-to-build and demand uncertainty on investment and prices/Dynamic Games Model	Dry Bulk/Entire World	Investment	Second-hand ship prices Scrap Value Profits Shipbuilding Prices	Their findings showed that the investment volatility is significantly higher as building time declines. Also, prices are less volatile as time to build declines	Kalouptsidi (2014)
6	Analysing the nexus between freight rate, newbuilding, second-hand vessel price/The Tri-variate GARCH model	Dry Bulk/Entire world	The conditional covariances between: - Freight rate-newbuilding market - Freight rate-second-hand market - Newbuilding-second-hand market	Volatility of - Freight rate - Newbuilding price - Second-hand price	Their results prove the existence of significant bilateral and unidirectional interactions among the freight rate market, Newbuilding vessel and second-hand vessel market.	Dai et al. (2015)
7	The relationship between investment boom and bust cycles and returns on capital/Asset Pricing Approach	Dry Bulk/Entire world	Excess return	Real Earnings Real Price Investment	The firms overinvest during booms and are disappointed by the subsequent low returns.	Greenwood and Hanson (2015)
8	Analysing the time-varying risk and price fluctuations for the second-hand ships/ARIMA-ARCH model	Tanker/Entire world	Second-hand ship prices (Aframax, Suezmax, VLCC)	Oil prices Freight rates Interest Rates Freight Market Balance Variable	Oil prices and second-hand ship prices negatively correlated, while oil prices and price volatilities positively correlated. Large vessels are riskier than smaller vessels in the tanker market.	Kavussanos (1996)

Table 1. *Cont.*

	Scope and Approach	Dataset/Sample	Dependent Var. (Output)	Independent Var. (Input)	Key Findings	Study/Authors
9	Analysing the investment timing and divestment decisions/The Stationary Bootstrap Approach	Tanker/Entire world	Investment/Divestment (Handysize, Suezmax, VLCC)	Five-year old Ship Prices Time charter rates Price/Earnings	The relationship between price and earnings in shipping markets contains important information about the future behavior of ship prices. The volatility in prices of larger vessel is higher than in smaller ones.	Alizadeh and Nomikos (2006)
10	Investment decision modelling new building vs second-hand/Error correction model	Tanker/Entire world	Second-hand Price/New Building Price	Avg. time charter rate Sale and buy market transactions Cost per gross tonnage Freight rate volatility Price of crude oil LIBOR	In a booming freight market, a ship-owner needs to buy a second-hand vessel, as it can be capitalised in the strong freight market. When the freight drops, the ship-owner should order new vessels, due to the optimism regarding the recovery of the market in the future.	Merikas et al. (2008)
11	Analysis of newbuilding prices, time charter rates and second-hand ship prices/Johansen's VAR	Container/Entire world	New building price index	Containership Time charter Rate Index Second-hand Prices Index	In a decreasing market, the newbuilding price is more active than the time charter rate and the second-hand price. In an increasing market instead, the time charter rate is more active	Fan and Yin (2015)
12	Capacity expansion and ship choice decisions analysis /Binary choice and nested logit models	153 Shipping Companies/Container Market	Capacity expansion decision Ship investment (NB-SH) and vessel type decision	Fixed cost per ship Capital cost Total market demand Avg. size of the vessel Size of the company Freight rates Container throughput The ratio of chartered capacity to total capacity Total capacity of company Company's market share The average vessel size Freight rates Newbuilding price Second-hand price The unit investment cost Ship construction lag	Most expansion decisions are market-driven, and large companies expand to maintain their market shares They found that ship companies decide first new order or second-hand before ship size. Also, new orders are preferable to second-hand. The substitution of new orders and second-hand purchases is possible, but not symmetrical	Fan and Luo (2013)
13	Freight rate relations with ship building decision/3SL method	Container/Entire world	Container throughput	Freight rate Fleet capacity Bunker price Delivery Scrap New Order	They analysed freight rate cyclical effect under the demand and supply effect. Also, they had some prediction about future freight rate after Global Financial Crisis, 2008.	Luo et al. (2009)

5. Conclusion and Future Works

The paper elaborated two distinctive subjects: the theoretical review of the firm-level investment theories and ship investment literature. The first part was undertaken to provide the theoretical review of the firm-level investment theories along with their main features and critiques. The second part was constructed to assess the literature on ship investments, in particular, to reveal existing literature in the context of newbuilding, second-hand and freight market relationships by two main vessel types, Bulk and Container Shipping.

The firm-level investment theories have shown continuous advancement to identify the maximum level of firm value by dissolving the drawbacks of the previous investment models over the period of the 1900s to 1970s. Indeed, five mainstream theories; accelerator, expected profit, liquidity, neoclassical and Q theory, provided that most of the investment theories deal with determinants of investments by assuming either instantaneous adjustment or distributed lag structure which is not related to any optimisation process. The latest and advanced Q theory is the only exception which contains theoretical foundations to allow a study of investment determinants in accordance with economic relationship. This allows gathering more plausible output by capturing broader information on investment and economic relationship.

The firm-level investments in fixed capital are central to the understanding of economic activities. The considerable fluctuation in investment expenditures can lead to aggregate fluctuations in the industry and the economy. Insufficient firm level investments closely link to reduced long-run industrial growth, and this might lead to waste of sources and oversupply problems in the short term. The firm-level investment decision is thus a crucial topic on steady industrial growth along with economic growth. To interpret the firm level investment decision within empirical approach by applying investment theories to either firm-level studies or industry level studies is crucial in the context of maximizing the firm/industry value by reaching optimum level and asset price valuation link. In the literature, firm-level investment theories recently and previously applied to various industries; such as manufacturing, finance, banking, housing and airline; and most of the studies proved that the explanatory power of investment theories could not be ignored.

In the shipping industry, the application of firm-level investment theories is not widely adopted. The studies in the ship investment literature mostly analysed the relationship among the shipping markets (newbuilding, second-hand, freight rate and scrap) and their individual/multiple impacts on asset price valuation, the timing of investments and market entry and exit conditions. Although the industry is highly capital intensive and attracts a high amount of investment, insufficient research has been undertaken focusing on maximising the firm/industry value by reaching optimum level and asset price valuation. The existing firm-level investment theories require adaptation to explain the investment decision by ship owners. Particularly given the structure of the bulk and container sectors, the decision might be driven more by expectations of future market conditions rather than asset prices and financial market conditions. This is supported by the existing studies that mostly focus on asset prices and the ratio of new and second-hand ships which is an indication of future expectations, rather than an evaluation of firm's value.

In the context of existing literature in ship investments, further research should be undertaken to investigate the decision-making process on ship investments through firm-level investment theories to examine the industry with the microeconomic approach. Utilizing investment theories might produce comprehensive findings to define firm-level value maximisation within the approach of the robust investment theories. Therefore, each firm might take advantage of defining the maximum level of firm value to manage investment funds in the long run.

The extensive theoretical foundation of firm-level investment theories and the literature of ship investments, the application of Q model in shipping industry might be more feasible. The Q variable for shipping industry might be defined as the ratio of existing ship prices to the construction costs of new building stand for the ratio of the firm's market value to its replacement cost.

References

Alizadeh, A., & Nomikos, N. (2006). Trading strategies in the market for tankers. Maritime Policy & Management, 33(2), 119-140.

Alizadeh, A., & Nomikos, N. (2007). Investment timing and trading strategies in the sale and purchase market for ships. Transportation Research Part B: Methodological, 41(1), 126-143.

Anderson, W. H. L. (1964). Corporate finance and fixed investment: an econometric study: Division of Research, Graduate School of Business Administration, Harvard University.

Arrow, K. J. (1962). The Economic Implications of Learning by Doing. The Review of Economic Studies, 29(3), 155-173.

Baddeley, M. C. (2002). Investment in an uncertain world. Zagreb International Review of Economics and Business, 5(2), 1-21.

Balliauw, M. (2017). An Analysis of Entry and Exit Decisions in Shipping Markets Under Uncertainty. International Journal of Shipping and Transport Logistics, 9(5), 527-539

Barro, R. J., & Martin, X. S.-i. (2004). Economic Growth (Second ed.): The IMT Press.

Bendall, H., & Stent, A. (2007a). Maritime investment strategies with a portfolio of real options. Maritime Policy & Management, 34(5), 441-452.

Bendall, H. B., & Stent, A. F. (2005). Ship investment under uncertainty: Valuing a real option on the maximum of several strategies. Maritime Economics & Logistics, 7(1), 19-35.

Bendall, H. B., & Stent, A. F. (2007b). Maritime investment strategies with a portfolio of real options. Maritime Policy & Management, 34(5), 441-452. doi:10.1080/03088830701585183

Bolton, P., Chen, H., & Wang, N. (2011). A unified theory of Tobin's q, corporate investment, financing, and risk management. The journal of Finance, 66(5), 1545-1578.

Bond, S., & Van Reenen, J. (2007). Microeconometric models of investment and employment. Handbook of econometrics, 6, 4417-4498.

Brainard, W. C., & Tobin, J. (1968). Pitfalls in financial model building. The American Economic Review, 99-122.

Broeze, F. (2002). The Globalisation of the Oceans: Containerisation from the 1950s to the Present: International Maritime Economic History Association.

Buckley, J. J. (2008). The business of shipping: Cornell Maritime Press.

Caballero, R., Engel, E., Haltiwanger, J., Woodford, M., & Hall, R. (1995). Plant-level adjustment and aggregate investment dynamics. Brookings papers on economic activity, 1-54.

Celik Girgin, S., Nguyen, H.-O., & Karlis, T. (2017). Revisiting the Effect of Financial Development on Economic Growth after 2008 Global Financial Crisis. Advances in Economics and Business, 5(8), 456-465.

Chang, H.-J. (2014). Economics: The User's Guide. London: Penguin Group.

Chenery, H. B. (1952). Overcapacity and the acceleration principle. Econometrica: Journal of the Econometric Society, 1-28.

Cheng, P. C. (1979). Financial management in the shipping industry: Cornell Maritime Pr/Tidewater Pub.

Chirinko, R. S. (1993). Business fixed investment spending: Modeling strategies, empirical results, and policy implications. Journal of Economic Literature, 31(4), 1875-1911.

Clark, J. M. (1917). Business acceleration and the law of demand: A technical factor in economic cycles. Journal of Political Economy, 25(3), 217-235.

Dai, L., Hu, H., & Zhang, D. (2015). An empirical analysis of freight rate and vessel price volatility transmission in global dry bulk shipping market. Journal of Traffic and Transportation Engineering (English Edition), 2(5), 353-361. doi:10.1016/j.jtte.2015.08.007

Dikos, G. (2008). Real options econometrics for aggregate tanker investment decisions. International Journal of Ocean Systems Management, 1(1), 31-44.

Dikos, G., & Marcus, H. S. (2003). The Term Structure of Second-hand Prices: A Structural Partial Equilibrium Model. Maritime Economics & Logistics, 5(3), 251-267. doi:10.1057/palgrave.mel.9100084

Dixit, A., & Pindyck, R. (1994a). Investment under uncertainty: Princeton university press.

Dixit, A. K., & Pindyck, R. S. (1994b). Investment under uncertainty: Princeton university press.

Duesenberry, J. S. (1958). Business cycles and economic growth. New York: McGraw-Hill Book Company.

Eisner, R., & Strotz, R. (1963). Determinants of Business Investment,[w:] Commission on Money and Credit, Impacts of Monetary Policy. In: Prentice Hall, Englewood Cliffs, NJ.

Eklund, J. E. (2010). Q-theory of investment and earnings retentions—evidence from Scandinavia. Empirical Economics, 39(3), 793-813.

Ericson, R., & Pakes, A. (1995). Markov-perfect industry dynamics: A framework for empirical work. The Review of Economic Studies, 62(1), 53-82.

Fan, L., & Luo, M. (2013). Analyzing ship investment behaviour in liner shipping. Maritime Policy & Management, 40(6), 511-533. doi:10.1080/03088839.2013.776183

Fan, L., & Yin, J. (2015). Analysis of structural changes in container shipping. Maritime Economics & Logistics, 18(2), 174-191. doi:10.1057/mel.2014.38

Fisher, I. (1930). The Theory of interest rates. New York.

Gkochari, C. C. (2015). Optimal investment timing in the dry bulk shipping sector. Transportation Research Part E: Logistics and Transportation Review, 79, 102-109.

Glen, D., & Martin, B. (2002). The Tanker Market: Current Structure and Economic Analysis. In C. Grammenos (Ed.), Handbook of Maritime Economics and Business (pp. 251-279). London: LLP.

Goodwin, R. M. (1948). Secular and Cyclical Aspects of the Multiplier and the Accelerator. Income, Employment and Public Policy: Essays in Honor of AH Hansen (various authors), New York: Norton, 108, 132.

Gould, J. P. (1968). Adjustment Costs in the Theory of Investment of the Firm. The Review of Economic Studies, 35(1), 47-55.

Greenwood, R., & Hanson, S. G. (2015). Waves in ship prices and investment. The Quarterly Journal of Economics, 130(1), 55-109.

Grunfeld, Y. (1960). The Determinants of Corporate Investment. In A. C. Harberger (Ed.), The Demand for Durable Goods (pp. 211-266). Chicago: University of Chicago Press.

Hall, R. E. (2001). The stock market and capital accumulation. American Economic Review, 91(5), 1185–1202.

Harlaftis, G., & Kostelenos, G. (2012). International shipping and national economic growth: shipping earnings and the Greek economy in the nineteenth century. The Economic History Review, 65(4), 1403–1427.

Harlaftis, G., Tenold, S., & Valdaliso, J. M. (2012). Epilogue: A Key Industry or an Invisible Industry? In G. Harlaftis, S. Tenold, & J. Valdaliso (Eds.), The World's Key Industry History and Economics of World Shipping (pp. 263-272). UK: Palgrave Macmillan.

Hayashi, F. (1982). Tobin's marginal q and average q: A neoclassical interpretation. Econometrica: Journal of the Econometric Society, 213-224.

Hopp, C., & Tsolakis, S. D. (2004). Investment applications in the shipping industry. Paper presented at the Proceedings of the 8th Annual International Conference on Real Options.

IMF. (2015). World Economic Outlook. Retrieved from Washington, D.C.

Jorgenson, D. (1963). Capital theory and investment behavior. The American Economic Review, 53(2), 247-259.

Jorgenson, D. (1967). The Theory of Investment Behavior. In R. Ferber (Ed.), Determinants of investment behavior: NBER.

Jorgenson, D. (1971). Econometric studies of investment behavior: a survey. Journal of Economic Literature, 9(4), 1111-1147.

Jorgenson, D., & Siebert, C. (1968). A comparison of alternative theories of corporate investment behavior. The American Economic Review, 681-712.

Kalecki, M. (1949). A new approach to the problem of business cycles. The Review of Economic Studies, 16(2), 57-64.

Kalouptsidi, M. (2014). Time to build and fluctuations in bulk shipping. The American Economic Review, 104(2), 564-608.

Kang, J. Y., Kim, S., Murphy, H., & Tenold, S. (2016). British financial, managerial and technical assistance in establishing the global shipbuilding giant, Hyundai Heavy

Industries. International Journal of Maritime History, 28(1), 81-101. doi:10.1177/0843871415622404

Karakitsos, E., & Varnavides, L. (2014). Maritime economics: A macroeconomic approach: Springer.

Kavussanos, M. (1996). Price risk modelling of different size vessels in the tanker industry using autoregressive conditional heterskedastic (ARCH) models. Logistics and Transportation Review, 32(2), 161.

Keynes, J. M. (1936). The general theory of employment, interest and money. London, 1936. KeynesThe General Theory of Employment, Interest and Money1936.

Kilponen, J., & Verona, F. (2016). Testing the Q theory of investment in the frequency domain. Bank of Finland Research Discussion Paper, 32.

Klein, L. R. (1951). Studies in Investment Behavior. NBER, Conference on Business Cycles, 233-318.

Kopcke, R. W. (2001). The performance of traditional macroeconomic models of businesses' investment spending. New England Economic Review(2), 3.

Koyck, L. M. (1954). Distributed lags and investment analysis. Amsterdam: North-Holland Publishing Company.

Kuh, E. (1963). Capital stock growth: A micro-econometric approach. Amsterdam: North Holland Publishing Company.

Li, M. Z., Oum, T. H., & Zhang, Y. (2004). Tobin’s q and airline performances. Public Works Management & Policy, 9(1), 51-65.

Lucas Jr, R. E. (1967). Adjustment costs and the theory of supply. Journal of Political Economy, 75(4, Part 1), 321-334.

Luo, M., Fan, L., & Liu, L. (2009). An econometric analysis for container shipping market. Maritime Policy & Management, 36(6), 507-523. doi:10.1080/03088830903346061

Markowitz, H. (1952). Portfolio Selection. The journal of Finance, 7(1), 77-91.

Marlow, P. B. (1991a). Shipping and investment incentives: a trilogy. Maritime Policy & Management, 18(2), 123-138.

Marlow, P. B. (1991b). Shipping and investment incentives: a trilogy† Part 2. Investment incentives for shipping. Maritime Policy and Management, 18(3), 201-216.

Marlow, P. B. (1991c). Shipping and investment incentives: a trilogy† Part 3. The effectiveness of investment incentives for shipping—the UK experience 1950–1987. Maritime Policy and management, 18(4), 283-311.

McCloskey, D. N. (2002). The secret sins of economics (Vol. 4): Prickly Paradigm.

McCloskey, D. N. (2006). Bourgeois Virtue. Chicago: University of Chicago Press.

Merikas, A. G., Merika, A. A., & Koutroubousis, G. (2008). Modelling the investment decision of the entrepreneur in the tanker sector: choosing between a second-hand vessel and a newly built one. Maritime Policy & Management, 35(5), 433-447. doi:10.1080/03088830802352053

Metaxas, B. N. (1971). The economics of tramp shipping: Athlone Pr.

Meyer, J. R., & Glauber, R. R. (1964). Investment decisions, economic forecasting, and public policy. Boston: Division of Research, Harvard Business Shool.

Meyer, J. R., & Kuh, E. (1957). The investment decision: An empirical study: Cambridge, Mass.: Harvard University Press.

Paine, L. (2014). The sea and civilization: a maritime history of the world: Atlantic Books Ltd.

Pakes, A., Ostrovsky, M., & Berry, S. (2007). Simple estimators for the parameters of discrete dynamic games (with entry/exit examples). The Rand journal of economics, 38(2), 373-399.

Papapostolou, N., Pouliasis, P., & Kyriakou, I. (2017). Herd behavior in the drybulk market: an empirical analysis of the decision to invest in new and retire existing fleet capacity. Transportation Research Part E: Logistics and Transportation Review, 104, 36-51.

Peters, R., & Taylor, L. (2017). Intangible capital and the investment-q relation. Journal of Financial Economics, 123(2), 251-272.

Romer, D. (2006). Advanced Macroeconomics. New York: McGraw Hill/Irwin.

Rua, A. (2011). A wavelet approach for factor-augmented forecasting. Journal of Forecasting, 30(7), 666-678.

Skjeggedal, E. (2012). The Q Theory Model of Housing: A Macroeconomic Analysis of the Dynamics in the Norwegian Housing Market. NORGES HANDELSHØYSKOLE, Norway.

Stopford, M. (2009). Maritime Economics (3rd ed.). London: Routledge.

Talley, W. K. (2011). The Blackwell companion to maritime economics (Vol. 13): John Wiley & Sons.

Tinbergen, J. (1938). Statistical evidence on the acceleration principle. Economica, 5(18), 164-176.

Tinbergen, J. (1939). Statistical Testing of Business Cycle Theories: Part I: A Method and Its Application to Investment Activity.

Tobin, J. (1969). A general equilibrium approach to monetary theory. Journal of money, credit and banking, 1(1), 15-29.

Tobin, J. (1978). Monetary policies and the economy: the transmission mechanism. Southern economic journal, 421-431.

Tsiang, S.-C. (1951). Accelerator, theory of the firm and the business cycle. The Quarterly Journal of Economics, 65(3), 325-341.

Tsolakis, S. D., Cridland, C., & Haralambides, H. E. (2003). Econometric Modelling of Second-hand Ship Prices. Maritime Economics & Logistics, 5(4), 347-377. doi:10.1057/palgrave.mel.9100086

UNCTAD. (2016). Review of Maritime Transport. Retrieved from Geneva, Switzerland: https://unctad.org/en/PublicationsLibrary/rmt2016_en.pdf

UNCTAD. (2017). Review of Maritime Transport. Retrieved from Geneva, Switzerland: https://unctad.org/en/PublicationsLibrary/rmt2017_en.pdf

Uzawa, H. (1965). Optimal Technical Change in an Aggregative Model of Economic Growth. International Economic Review, 6(1), 18-31.

Veenstra, A. W., & De La Fosse, S. (2006). Contributions to maritime economics—Zenon S. Zannetos, the theory of oil tankship rates. Maritime Policy & Management, 33(1), 61-73. doi:10.1080/03088830500513444

Zannetos, Z. S. (1966). The theory of oil tankship rates: Massachusetts Institute of Technology.

Paper 2: Valuation mismatch and shipping q indicator for shipping asset management

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Abstract: This paper aims to develop an adaptation of the Tobin Q investment model for the shipping asset management in order to monitor valuation mismatch and bubble pricing of shipping assets. In this circumstance, the market prices of various shipping assets (e.g., Capesize or Panamax dry bulk carriers in different age profiles) are compared to the measured long-term asset value with second-hand ship prices. The mark-to-market prices of shipping assets are led by current market trends and freight rates, while the long-term asset value is estimated by using past data under certain assumptions (mean reversion, trend reversion). The discrepancy between market prices and the long-term nominal value of a shipping asset reflects any mispricing, which in turn sheds light on investment timing and market entry-exit decision.

Keywords: Shipping asset management; ship valuation; Tobin Q theory; investment

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